

3445A AC/DC RANGE UNIT

OPERATING AND SERVICE MANUAL



CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.



MANUAL CHANGES

MODEL 3445A

Manual Serial Prefixed: 512-

HP Part No. 03445-90000

Instrument Serial Number	Make Manual Changes	Instrument Serial Number	Make Manual Changes
ALL	ERRATA		
see below #	1		

HP Part No. and HP Stock No. are synonymous

512-00201 and above and:

	512-00172	512-00190
512-00158	512-00175	512-00192
512-00161	512-00186	512-00194
512-00171	512-00193	512-00196

CHANGE 1:

Section VI, Replaceable Parts, and Figure 5-6, Converter Schematic:

Change A4R25* to A4R25.

Change A4R24 to A4R24*.

Change A4R33 to A4R33* average value 6800, -hp- Part No. 0683-6825.

Change A4R32 to 1800 ohms, -hp- Part No. 0683-1825.

Change A4R12 to 11 K ohms, -hp- Part No. 0683-1135.

Change A3R17* average value to 4220, -hp- Part No. 0698-3346.

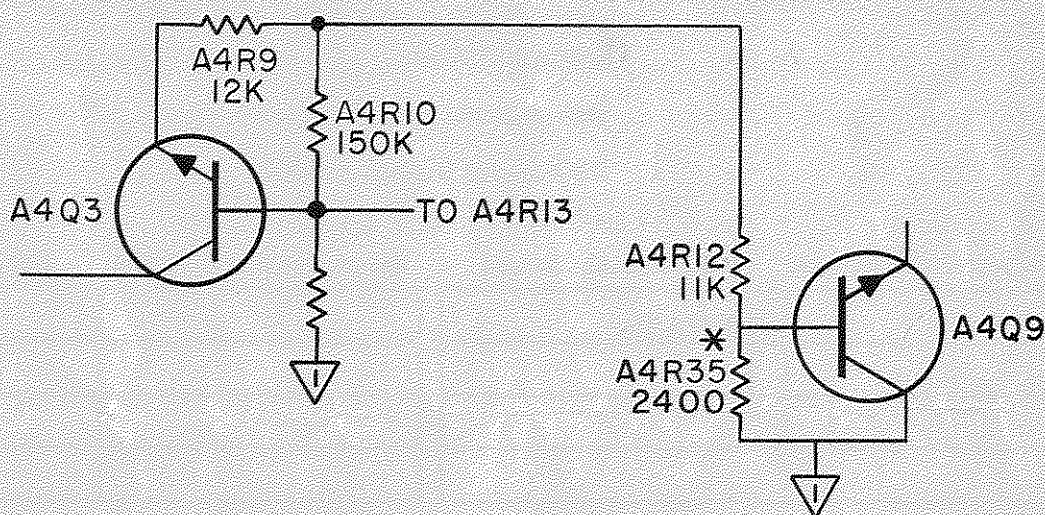
Section VI, Replaceable Parts:

Change A1Q1 from -hp- Part No. 1855-0004 to 1855-0006, type SU414.

Change A4Q7 from -hp- Part No. 1854-0069 to 1854-0089, Mfr. Fairchild, type SE7010.

Figure 5-6, AC Converter Schematic:

Change the connection to A4R12 as in the partial schematic at the top of the following page.



ERRATA:

Table 1-1, Specifications:

Change VOLTAGE ACCURACY (AC) to read as follows:

- 50 cps to 20 Kc $\pm 0.1\%$ of reading ± 2 counts
- 20 Kc to 50 Kc $\pm 0.1\%$ of F. S. ± 2 counts
- 50 Kc to 100 Kc, linearly derated from $\pm 0.1\%$ of F. S. ± 2 counts at 50 Kc to $\pm 0.3\%$ of F. S. ± 2 counts at 100 Kc.

Table 4-1:

Change to the following:

Title, Correlation between Figure 4-1 and Figure 5-6.

Resistors in Block Diagram Figure 4-1	Corresponding Impedances in Figure 5-6
R1 (all ac ranges)	A2R1, A2C2, A2C3
R2 (shorted by K4, 10 v range)	A1R2, A2C8, A2C9
R3 (connected to  by K3, 1000 v range)	A2C4, A2C5, A2R3, A2R4
R5 (connected to  by K2, 100 v range)	A2C6, A2C7, A2R2, A2R5
R17 (feedback)	A1R17, A1C1, A1C2

Paragraph 4-12, line 7:

Change "field effect transformer" to "field effect transistor."



OPERATING AND SERVICE MANUAL

(HP PART NO. 03445-90000)

MODEL 3445A
AC/DC RANGE UNIT

SERIALS PREFIXED: 512-

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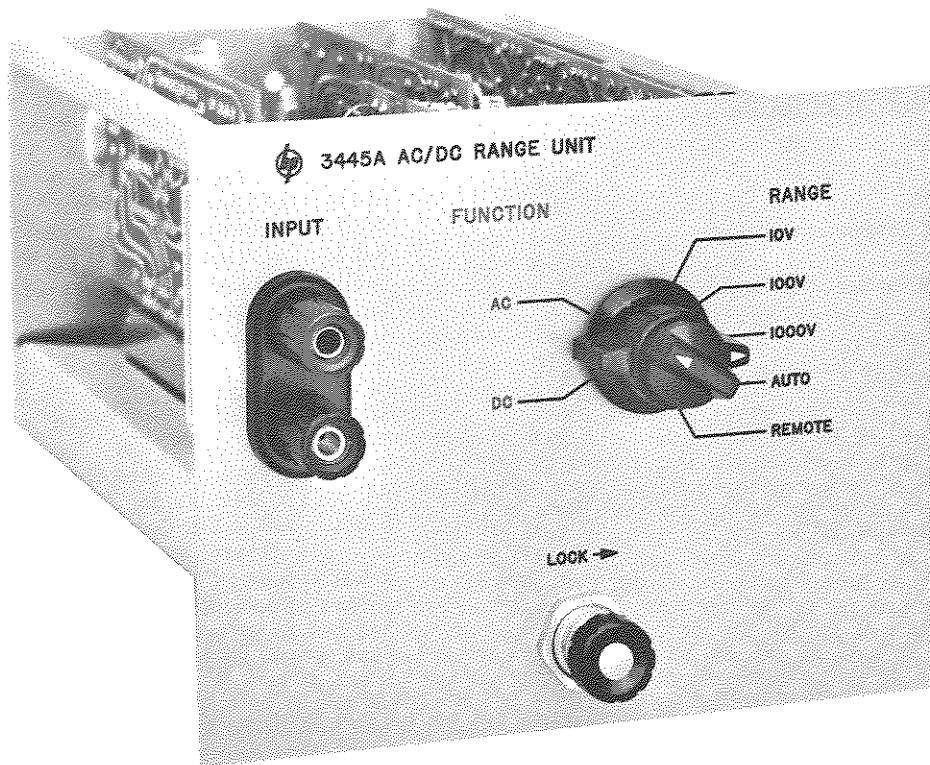


Figure 1-1. Model 3445A AC/DC Range Unit

Table 1-1. Specifications

VOLTAGE RANGE (AC and DC): 4-digit presentation of 9.999, 99.99, and 999.9 volts full scale with 5% overrange capability and overrange indicator.

VOLTAGE ACCURACY (AC): From 20°C to 30°C, including line variations of $\pm 10\%$ from nominal:
50 cps to 20 Kc, $\pm 0.1\%$ of reading ± 2 counts
20 Kc to 50 Kc, $\pm 0.1\%$ of reading ± 2 counts
50 Kc to 100 Kc, linearly derated from $\pm 0.1\%$ F.S. ± 2 counts at 50 Kc F.S. ± 2 counts at 100 Kc
Temperature coefficient of accuracy: $\pm 0.005\%/^{\circ}\text{C}$
TC applies from 0°C to +20°C (use +20°C as zero TC reference point) and from +30°C to +50°C (use +30°C as zero TC reference point).

VOLTAGE ACCURACY (DC): $\pm 0.05\%$ of reading ± 1 digit including line voltage variations of $\pm 10\%$ from nominal. A front panel adjustment on the 3440A insures accuracy over the temperature range between +15°C and +40°C and $\pm 0.1\%$ ± 1 digit over the temperature range of 0°C to +15°C and 40°C to 50°C.

RANGE SELECTION (AC): With 3445A: Manual, automatic and remote; range change speed: automatic; achieves proper range within 2 seconds following a sample. Remote will change range within 40 ms.

RESPONSE SPEED (AC): Achieves specified accuracy within 3 seconds when on proper range. Allow an extra second for overload recovery when overloaded.

RANGE SELECTION (DC): With 3445A: Manual, automatic and remote; range change speed: automatic achieves specified accuracy in less than 1 second following a sample. Remote will change range within 40 ms.

INPUT IMPEDANCE: 10 megohms shunted by 20 pf nominal on all ac ranges; 10.2 megohms on all dc ranges.

INPUT FILTER CHARACTERISTICS (DC): Response time: less than 450 ms to a step function to within 99.95% of final value. (Without a range change.)

INPUT FILTER AC REJECTION: 10, 100, 1000 volt ranges: 30 db at 60 cps, increasing at 12 db/octave.

COMMON MODE REJECTION (DC):

	10 v Range	100 v Range	1000 v Range
DC	90 db	70 db	50 db
60~	70 db	50 db	30 db

POLARITY: Automatic indication.

WEIGHT: Net: 2.75 lbs (1.24 Kg),
Shipping: 5.2 lbs (2.34 Kg).

DIMENSIONS: 6" (12.25 cm) wide, 4-11/16" (11.90 cm) high, 9-1/8" (23.15 cm) long.

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Model 3445A AC/DC Range Unit and the -hp- Model 3440A Digital Voltmeter combination measures dc volts and ac volts with four digit resolution. This combination makes it possible to measure either dc or ac voltages in three ranges with full-scale readouts of 9.999 volts, 99.99 volts and 999.9 volts. The 3445A provides for three types of operations: 1) Manual, 2) Automatic Ranging and 3) Remote Control. The -hp- Model 3445A is shown in Figure 1-1; specifications are given in Table 1-1.

1-3. The INPUT terminals on the 3445A are used for both dc and ac voltages. When the 3445A is inserted into the plug-in compartment of the 3440A, the input terminals on the 3440A are disconnected from the attenuator and cannot be used for operation of the instrument.

1-4. PLUG-IN VARIATIONS.

1-5. The standard Model 3445A may be used in conjunction with a printer using 1-2-2-4 code. If a printer

using a 1-2-4-8 code is used, both the Model 3440A and the 3445A must be converted for this code. Converted instruments become specials identified by an alphameric prefix to the Model (i. e. H02-3445A).

1-6. INSTRUMENT IDENTIFICATION.

1-7. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 3445A described in this manual.

1-8. If E or G prefixes the serial number, the instrument is manufactured in Europe (E for England and G for Germany). These instruments are provided with manual change sheets if necessary to explain differences between the instrument and the manual.

SECTION II

INSTALLATION

2-1. INCOMING INSPECTION.

2-2. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free from marks or scratches and in perfect electrical condition upon receipt. In addition to this, the instrument should be inspected on arrival for physical damage in transit. Also test the electrical performance of the instrument using the Performance Checks in Paragraph 5-5. If there is damage or a deficiency, see the warranty on the inside front cover of this manual.

2-3. INSTALLATION.

2-4. Install the Model 3445A in the compartment provided in the -hp- Model 3440A Digital Voltmeter. Make certain that the connector at the rear is inserted properly and the front panel locking screw is tightened.

2-5. REPACKAGING FOR SHIPMENT.

2-6. The following is a general guide for repackaging an instrument for shipment. If you have any questions, contact your local Sales and Service Office. (See list in Appendix B for locations.)

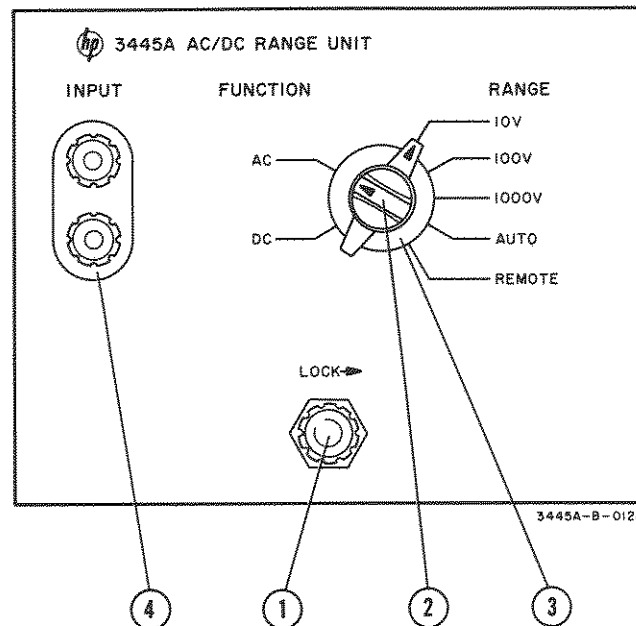
- a. Place instrument in original container if available. If not available, it may be purchased from your nearest -hp- Sales and Service Office.

If original container is not used,

- b. Wrap instrument in heavy paper or plastic before placing in inner container.
- c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.
- d. Use a heavy carton or wooden box to house the instrument and inner container and use strong tape or metal bands to seal the shipping container.
- e. Mark shipping container with "Delicate Instrument," or "Fragile."

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument.



- ① **LOCK:** When turned completely clockwise, the Model 3445A is locked securely in the compartment of the 3440A. When removed from this position, the lock must be turned completely to the counterclockwise position. This releases the spring and the 3445A slightly protrudes from the 3440A.
- ② **FUNCTION:** This switch is controlled by the center knob and selects either ac or dc voltage.
- ③ **RANGE:** This switch is controlled by the outer knob and either selects ranges manually (10 volts, 100 volts or 1000 volts), automatically or remotely.
- ④ **INPUT:** This GR connector is used to connect the input voltage to the Model 3440A Digital Voltmeter, for both ac and dc voltages. The INPUT terminals, normally used on the 3440A, are disconnected at the plug-in connector of the 3445A. This INPUT terminal on the 3445A has a floating common and cannot be connected to chassis ground except by a jumper wire to the 3440A $\frac{1}{2}$.

Figure 3-1. Front Panel Location

SECTION III

OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. The -hp- Model 3445A AC/DC Range Unit offers ac and dc voltage measurement in one plug-in unit. The 3445A has its own INPUT connector and a two-section RANGE and FUNCTION switch (see Figure 3-1).

3-3. OPERATION PROCEDURE.

3-4. Operating instructions for the Model 3445A AC/DC Range Unit are given in Figure 3-2. Instructions are keyed to the illustration of the 3440A and the 3445A front panel.

3-5. APPLICATIONS.

3-6. Both ac and dc voltages may be measured by the 3445A, 3440A combination by merely changing the position of the function switch. In AUTO position of the RANGE switch, the range is automatically selected by the amount of voltage that is applied to the INPUT terminals. The high accuracy, the high input impedance and resolution of the 3445A make it a very useful general purpose laboratory instrument. (See Specifications, Table 1-1.) Auto Ranging makes it possible to get a proper voltage reading without manually changing the range switch. Remote programming is possible when the range switch is in the REMOTE position. In the manual and remote positions of the RANGE switch, the 3445A has 5% overrange capability and overrange indication.

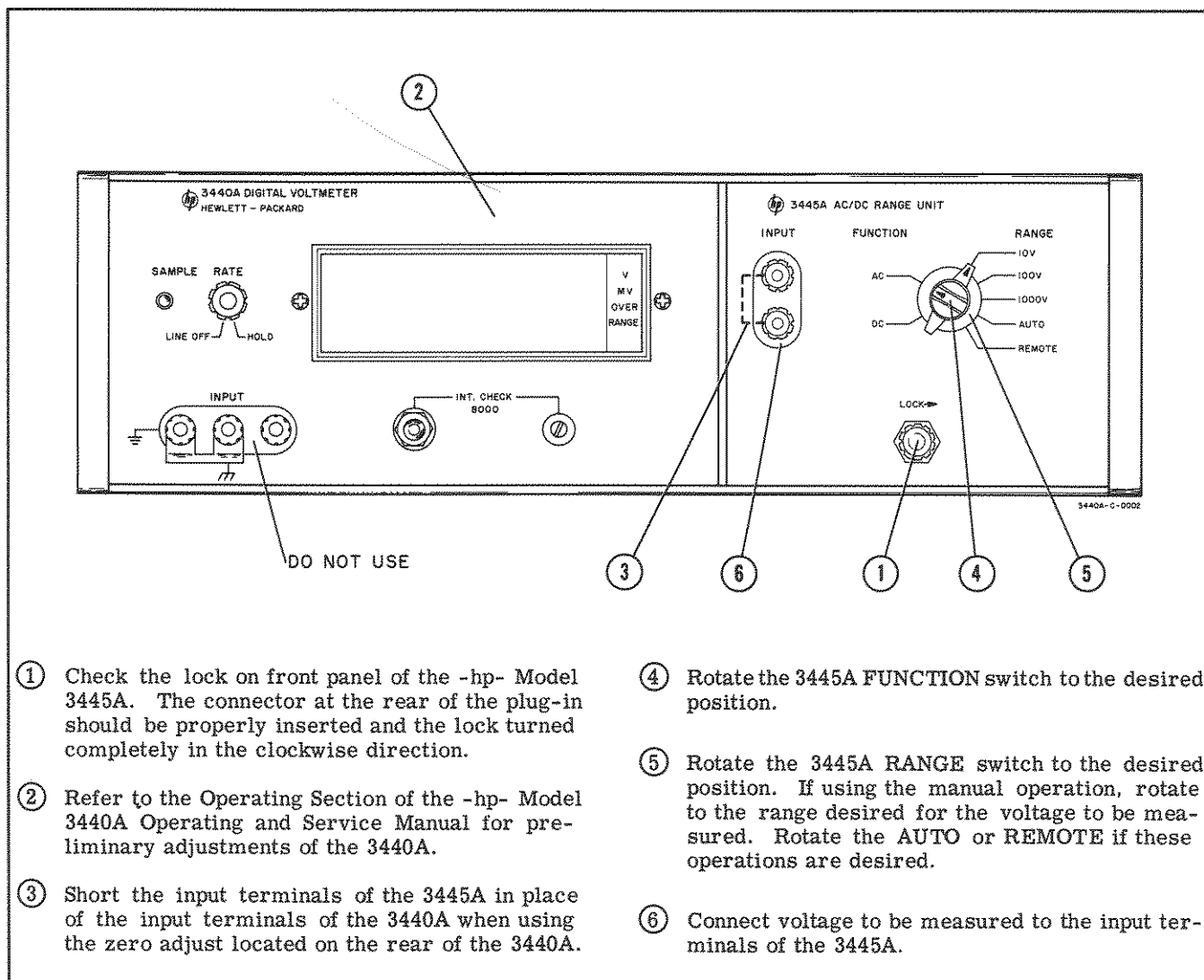


Figure 3-2. Operation

Section IV
Figure 4-1

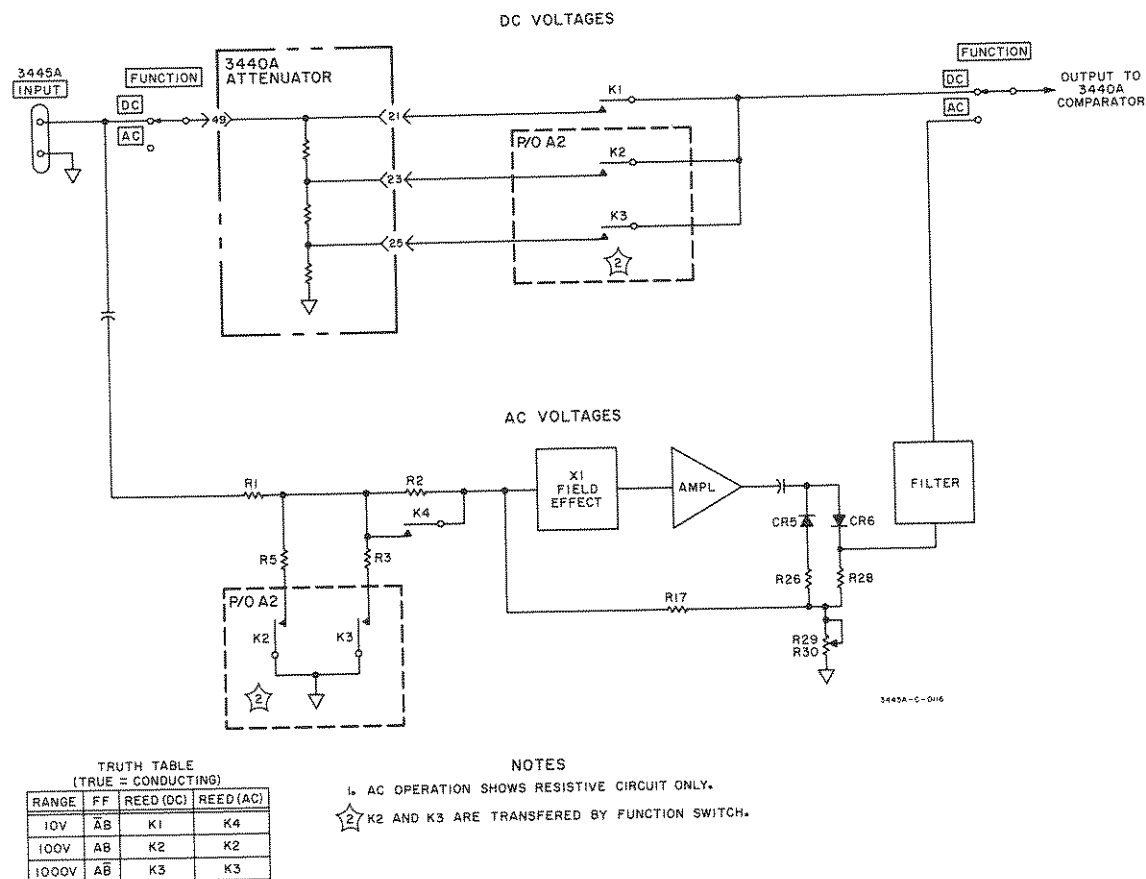


Figure 4-1. Block Diagram for DC and AC

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 3445A AC/DC Range Unit provides selection of either Automatic, Manual or Remote ranging for either dc or ac voltages. When inserted into the compartment provided by the -hp- Model 3440A Digital Voltmeter, the 3445A circuits act on the voltmeter circuits to:

- a. Select either ac or dc measurements.
- b. Select the proper voltage range or type of ranging.
- c. Provide function and decimal information for the recorder.

In Auto Ranging only:

- d. Inhibit the recorder to prevent erratic printing during change of range.
- e. Stop the voltmeter sampling for a short period of time permitting auto ranging for fast sample rates.
- f. Speedup the voltmeter sample rate while automatically changing ranges.

4-3. The explanation for the 3445A circuitry is divided into three sections, 1) Manual Operation, 2) Remote Control, and 3) Automatic Ranging; each includes both ac and dc voltage measurements.

4-4. MANUAL OPERATION.

4-5. Both ac and dc voltages in three ranges, 10 volts, 100 volts and 1000 volts, may be operated manually by combinations of the positions of the FUNCTION and RANGE switches. (See the Block Diagram for manual operation, Figure 4-1.)

4-6. DC OPERATION.

4-7. The input from the 3445A is connected to the 3440A Attenuator in the dc operation of the FUNCTION switch. The output from the appropriate tap on the attenuator is connected to the 3440A comparator through relays energized by the combination efforts of the RANGE and FUNCTION switches.

4-8. AC OPERATION.

4-9. The ac connector in the 3445A is permanently connected to the input terminals on the front panel of the plug-in. A blocking capacitor in the converter prevents interference when the same input terminals are used for dc volts. In the AC volts position of the FUNCTION switch, the 3440A dc attenuator is disconnected from the terminals and the dc polarity light is extinguished.

4-10. AC CONVERTER CIRCUIT.

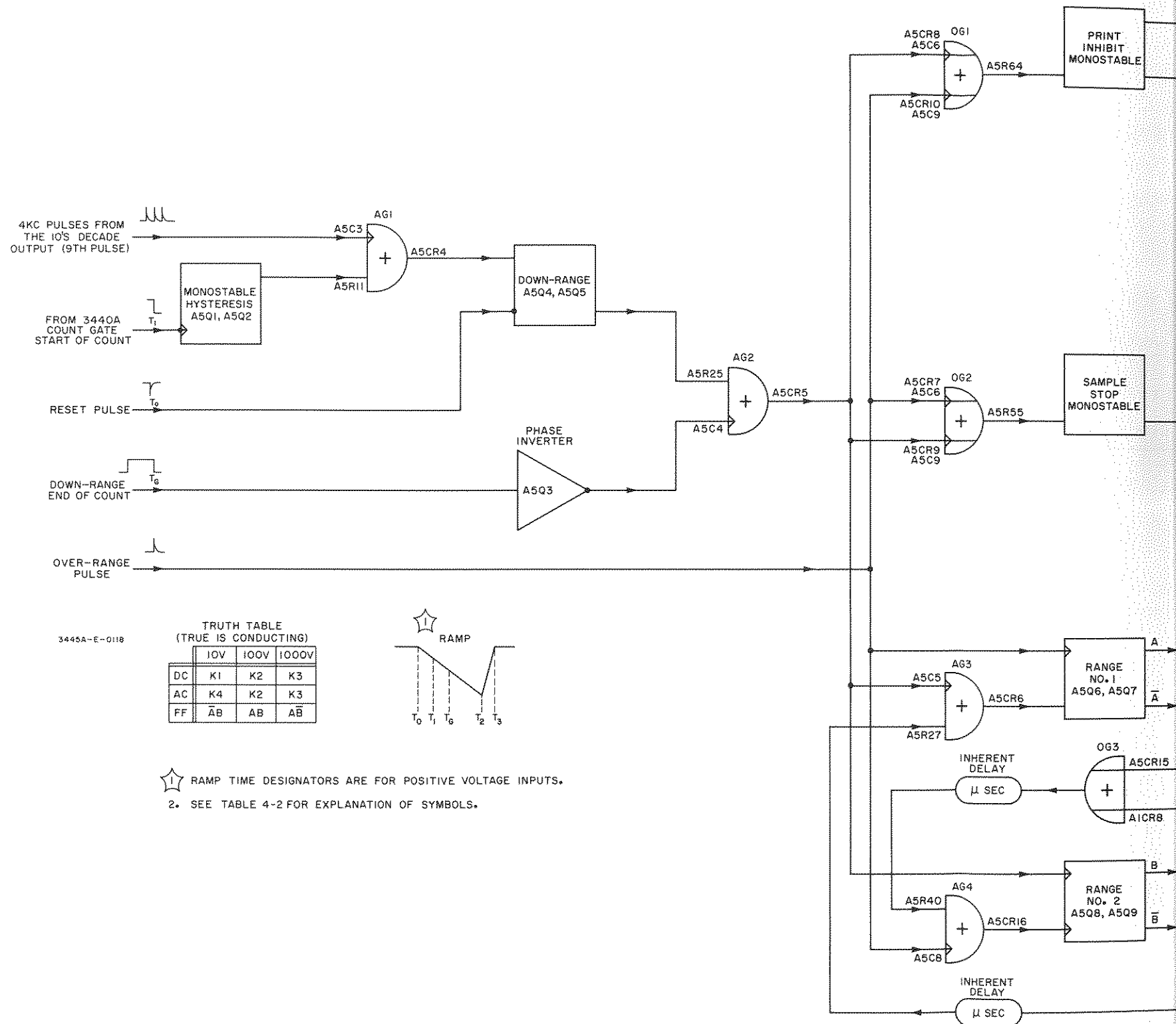
4-11. The ac converter in the 3445A employs a precision current to voltage conversion amplifier. Range change is accomplished by changing the transfer admittance (current out for voltage in) of the input attenuator. This is accomplished by three reed relays, one for each range (see the lower section of Figure 4-1, Block Diagram for DC and AC). Table 4-1, AC Ranging Transfer Impedances, shows the components associated with each resistor in this diagram.

Table 4-1. AC Range Transfer Impedances

AC Range	Resistor in Block Diagram	Corresponding Impedance Circuit
10 volt	R2 (shorted by K4)	A1R2, A2C8, A2C9
100 volt	R5 (connected to ∇ by K2)	A2R5, A2R2, A2C6, A2C7
1000 volt	R3 (connected to ∇ by K3)	A2R3, A2R4, A2C5
	R17 (feedback)	A1R17, A1C1, A1C2

4-12. The ac input signal passes through A2C1 into the input attenuator. The proper transadmittance is selected by energizing a different relay for each range. The short circuit current out of the attenuator is fed into the converter amplifier which precisely controls the voltage out to current in ratio. The signal path consists of A1Q1, field effect transformer operated in a common source configuration; A4Q1 and Q2, connected in a feedback pair, to give a precise voltage gain; A4Q4, Q5 and Q6 connected in a feedback triplet to give precise voltage gain with large dynamic range and low output impedance; and A4Q7 and Q8 connected in a common emitter, bootstrapped collector configuration to give high output impedance with large dynamic range. The ac signal is rectified by the bridge, consisting of A4CR5, CR6, R26, R28, and the rectified RCL filter. A voltage, proportional to the bridge current, is developed across A4R29, R30, A1R19, R20 and L2. This voltage is fed back to the gate of A1Q1 through A1R17, C1 and C2. The entire circuit is direct-coupled except for A4C9 and C14, to enhance overload recovery and facilitate the low frequency shaping.

4-13. A4Q3 is a low frequency feedback inverter used to stabilize the amplifier at frequencies from dc to the lowest measurement frequency. A4Q9 and A3Q7, Q8 and Q9 are regulator transistors to furnish the proper voltages for the amplifier. Bias adjustment is accomplished by A3R11 with A4R35 selected at the factory to insure the proper adjustment range.



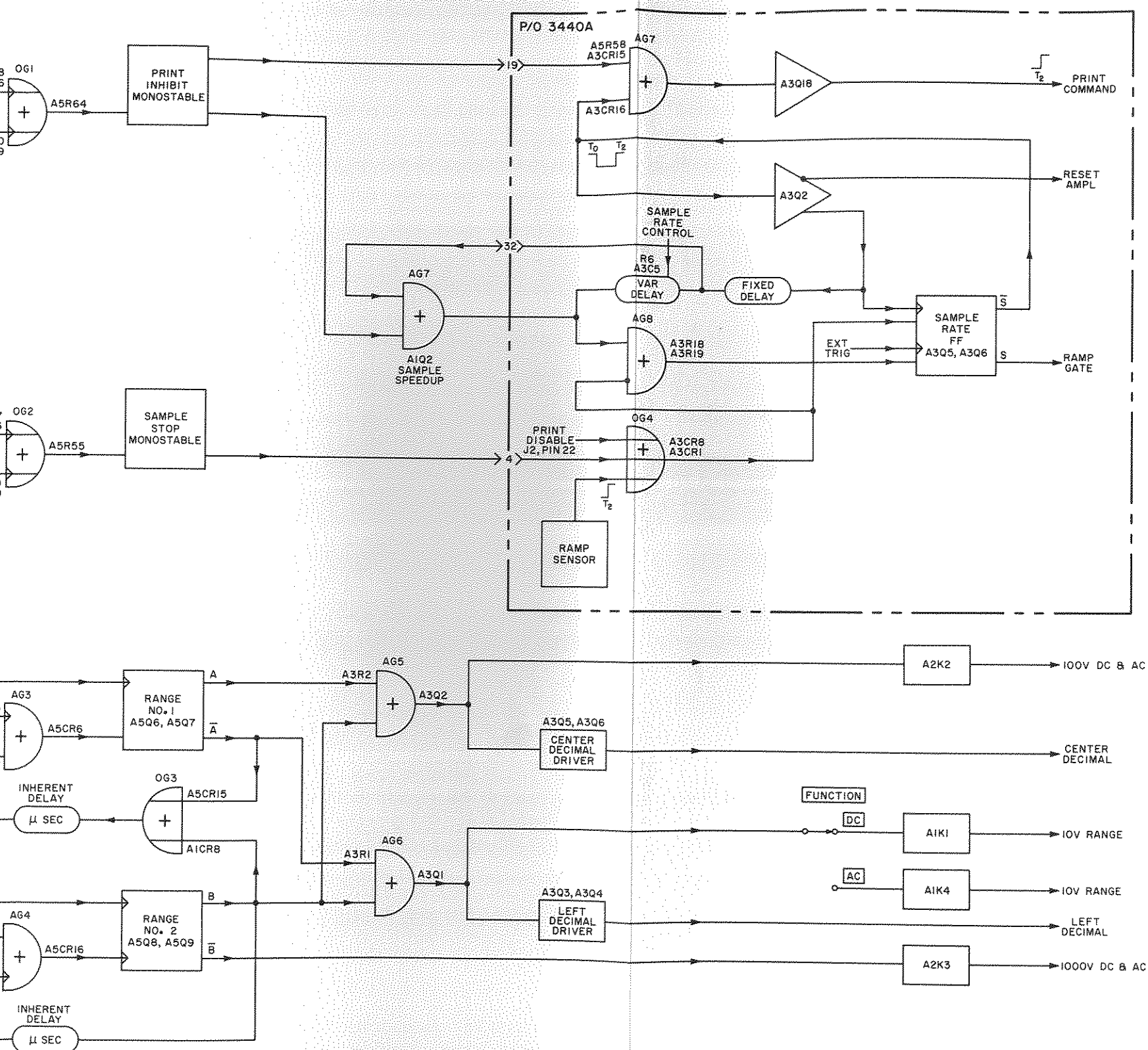


Figure 4-3. Auto Ranging Logic Diagram

Se
Ta

A
Ga

OR
Ga

Exc
OR

Mul
Inpu

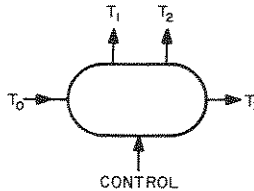
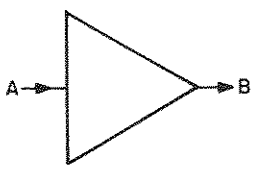
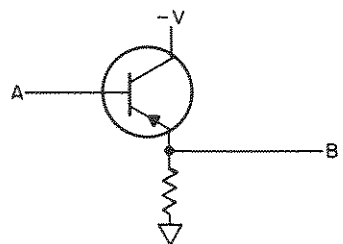
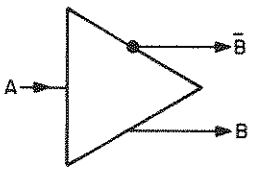
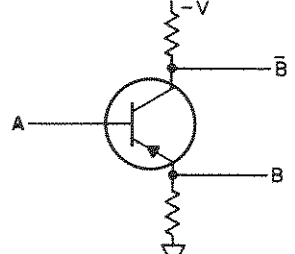
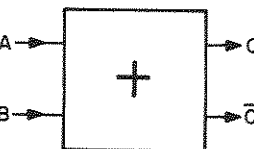
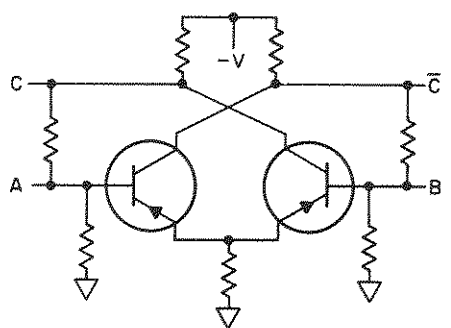
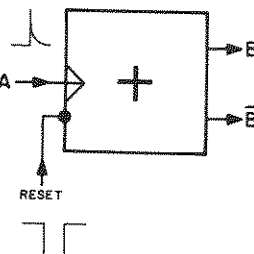
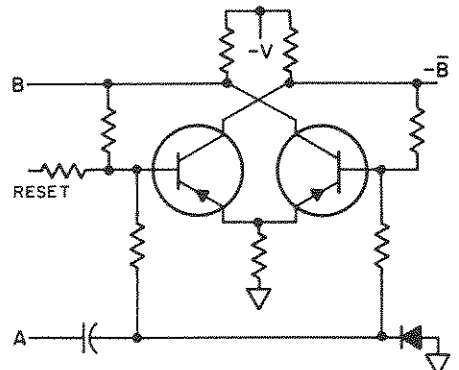
Table 4-2. Explanation of Logic Symboly
LOGIC SYMBOLS

+ within a symbol indicates positive true logic
- within a symbol indicates negative true logic
1 indicates true signal
0 indicates false signal

—| on symbol indicates dc coupling
—| on symbol indicates ac coupling
—• on symbol indicates logical inversion (not necessarily electrical)
→ indicates direction of signal flow

Desig.	Logic Symbol	Description	Truth Table	Equivalent Circuit																																				
AND Gate		Both input signals (A and B) must be true simultaneously to produce a true output at C.	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	C	0	0	0	0	1	0	1	0	0	1	1	1																						
A	B	C																																						
0	0	0																																						
0	1	0																																						
1	0	0																																						
1	1	1																																						
OR Gate		If either input signal (A or B) or both is true, the output at C is true. (A positive OR Gate is electrically equivalent to a negative AND Gate only when dc coupling is used.)	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	1																						
A	B	C																																						
0	0	0																																						
0	1	1																																						
1	0	1																																						
1	1	1																																						
Exclusive OR Gate		If either input signal (A or B), but not both, is true, the output at C is true.	<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	0																						
A	B	C																																						
0	0	0																																						
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1	0	1																																						
1	1	0																																						
Multiple Input Gate		Any combinations of inputs may be used with an AND or OR Gate to obtain a desired output. In the AND Gate shown, input A is ac coupled, input B is dc coupled and inverted, and input C is dc coupled without inversion. Inputs A and C must both be true, and input B must be false simultaneously to produce a true output at D.	<table><tr><th>A</th><th>B</th><th>C</th><th>D</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td></tr></table>	A	B	C	D	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	1	1	1	1	0	0	1	1	1	0	
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1	1	1	0																																					

Table 4-2. Explanation of Logic Symbology (Cont'd)

Desig.	Logic Symbol	LOGIC SYMBOLS Description	Equivalent Circuit
Passive Delay		Amount of delay depends on RC or RL time const.	RC or RL coupling
Amplifier		True input at A produces amplified true output at B. An amplifier will function with either positive true or negative true signals.	
Phase Splitter		True input at A produces true output at B and false output at B-bar (read as "B bar" or "B not").	
Flip-Flop		Outputs C and C-bar are always in opposite states -- if C is true C-bar is false. A true input will cause the output directly across to go true -- true input at A sets output C true. With no input the flip-flop remains in the state set by the last input signal. The flip-flop is considered to be in the zero state if output C is false.	
Binary		The binary is a flip-flop which changes state with every true input pulse at A. Since A is applied to the bases of both transistors, it is shown centered in the symbol. The negative pulse produces the same effect as a positive pulse applied to the opposite base. To preserve the positive logic, the reset pulse is shown inverted and applied to the opposite side.	

4-22. DOWNRANGING.

4-23. Assume that the -hp- Model 3445A, inserted in a 3440A, is in the DC position of the FUNCTION switch and on the 1000 volt range in the AUTO position of the RANGE switch. A2K3 is energized and the range multivibrators have A and $\bar{B}$ (read B bar or B not) conducting. A voltage is applied to the input that is smaller than 10 percent of the 1000 volts or less than 100 volts. At the beginning of the sample T_0 , the negative reset pulse is applied to the downrange multivibrator opening the number 2 "and" gate. At the beginning of the count, simultaneously, a signal is sent to the hysteresis multivibrator and the 400 Kc oscillator starts to operate sending the 4 Kc (9th pulse) signals to the 3445A. The hysteresis monostable multivibrator closes the number 1 "and" gate and it stays closed for 2.12 milliseconds. This prevents the first nine pulses of the oscillator from passing through the gate (1 pulse equals 1% of the voltage range). The tenth and successive pulses will pass through AG1 flipping the downrange multivibrator closing AG2. Whenever there is an input voltage of 10% or more of the operating range, the 3440A cannot be downranged. In this specific case, the input voltage is less than 10%. There is no 10th pulse and AG2 is open.

4-24. At the end of the count, a downrange negative pulse is sent to A5Q3, inverted and passed through AG2. From here it is sent to four places. 1) It is sent through OG2 to the sample stop multivibrator. This stops the sample for 0.1 to 0.2 seconds in order to provide time for auto ranging if the sample rate is too fast. 2) It is sent through OG1 to the print inhibit monostable multivibrator where for 1.3 seconds it stops the print command, preventing erratic printing during a change of range. It also is sent to the sample speed-up gate AG7 where it shorts out the variable sample rate delay, speeding up the sample for a quick change of range. (The sample stop overrides this signal for 0.1 to 0.2 seconds (AG8 is closed), then the sample speed-up takes over for the remaining portion of the 1.3 seconds.) 3) It is sent to the AG3 which is held closed by the negative voltage from B. This prevents any change in the No. 1 Range Multivibrator. 4) It is sent to No. 2 Range Multivibrator causing B to conduct. Thus, the conditions for the 100-volt range are met (A and B conducting). The positive voltages from A and B open AG5 energizing A2K2 and selecting the center decimal. A2K3 is de-energized, AG6 is closed and the 3445A downranges to the 100-volt range.

4-25. Now assume that the input voltage decreases to a point less than ten percent of 100 volts (less than 10 volts). The same sequences occur up to the range multivibrators. The previous condition was A and B conducting. The positive voltage from B opens AG3 allowing the downrange signal to cut off A causing $\bar{A}$ to conduct. $\bar{B}$ stays cut off and B is still conducting. This closes AG5 and opens AG6. Thus, A1K1 is energized, and the left decimal is lighted. These are the conditions for the 10-volt range. If a downrange signal arrives on the 10-volt range, AG3 is open but A and $\bar{B}$ are already cut off so it has no effect.

4-26. DC UPRANGING.

4-27. If the input voltage is greater than the range in operation while the 3445A is in the AUTO position of the RANGE switch, the 3445A will automatically up-range. Assume that the 3445A is now in the 10-volt range and the FUNCTION switch is in the DC position. An input voltage is applied greater than ten volts. There is an overflow from the thousands decade counter sent through A3 of the 3440A and thence to the 3445A. This positive pulse performs the same operation for the sample stop, sample speed-up and print inhibit as did the downrange pulse. When this positive pulse reaches the range multivibrators and $\bar{A}$ and B are conducting, the positive voltage from B opens AG3 allowing the overrange positive pulse to cut off A, causing $\bar{A}$ to conduct. AG4 is open but $\bar{B}$ is already cut off and B conducting. Now the conditions for the 100-volt range are met. A and B are conducting, AG5 is open, A2K2 is energized and the center decimal is lighted.

4-28. Assume a voltage greater than 100 volts is applied to the input of the 3445A. The overrange pulse is again applied to the 3445A. The same procedure occurs except for the range multivibrators. The pre-condition is: A and B conducting, $\bar{A}$ and $\bar{B}$ cut off. The over-ranging true pulse is applied to both range multivibrators. A is already true (conducting) so it has no effect. The positive voltage from B opens AG4 passing the over-range pulse. The inherent delay insures that the signal is there long enough to cut off B. $\bar{B}$ now conducts setting up the conditions for the 1000-volt range. When $\bar{B}$ conducts, A2K3 is energized placing the 3445A in the thousand volt range. Neither the center decimal or the left decimal is illuminated; therefore, the right decimal is lighted. If an overflow from the thousand's decade counter occurs in this range, nothing happens as the pre-conditions are set up for the thousand volt range.

4-29. AC AUTOMATIC RANGING.

4-30. The ac input voltage is converted to a dc voltage by the operational amplifier converter of the 3445A before it is sent to the comparator of the 3440A. The amplitude in dc volts is equal to the rms value of the input ac voltage after it has been corrected for range (10 volts dc output for full-scale readout in all ranges). The 3445A input signals from the 3440A are identical to that of a positive dc voltage input. Because of response time for the ac conversion, the monostable sample stop and print inhibit multivibrators have a longer recovery time. See the schematic Figure 5-7 for this variation. A5R66 and R67 are connected to A5R57 and R50 in the dc position of the FUNCTION switch. In the ac position, this connection is broken increasing the time constant and increasing the recovery time of the multivibrators. In ac operation, the recovery time of the print inhibit multivibrator is approximately 5 seconds. This is the time that the printer is inhibited to prevent erratic printing. The sample is stopped for approximately 0.5 seconds and then the sample is speeded up for the remaining portion of 5 seconds.

4-31. DECIMAL POINT OPERATION.

4-32. The left and center decimal points are controlled by a two-stage transistor switching device. The left decimal is controlled by A3Q3 and A3Q4; the center decimal by A3Q5 and A3Q6. The collector of A5Q8 (B) is connected through A3CR8 and CR7 to the emitters of A3Q4 and Q5. This turns both decimals off, if B is not conducting. (B is conducting on both the 10-volt range and the 100-volt range.) The collector of A5Q6 (A) is connected to the base of A3Q6, and the collector of A5Q7 ($\bar{A}$) is connected to the base of A3Q3. If A or $\bar{A}$ is conducting, the positive potential placed on the base of the corresponding transistor will cut it off. Thus, two conditions are necessary: B conducting and either A or $\bar{A}$ conducting. In the 10-volt range, B and $\bar{A}$ are conducting (see truth table); the positive voltage at the base of A3Q3 cuts it off, driving A3Q4 into saturation illuminating the left decimal.

In the 100-volt range A and B are conducting; the positive voltage at the base of A3Q6 cuts it off, driving A3Q5 into saturation, illuminating the center decimal. In the 1000-volt range A and $\bar{B}$ are conducting; B is cut off; neither the left nor the center decimal is illuminated. Thus, the right decimal is automatically lighted.

4-33. DIGITAL RECORDER INFORMATION.

4-34. Recorder information for function and range is furnished by the 3445A. For exact print-out see Section V of this manual. This information is sent from J6, output of the 3445A, directly to J2 RECORDER connector on the 3440A. It is then combined with the binary outputs, polarity and overrange information from the 3440A to complete the print-out on the recorder.

Table 5-1. Test Equipment Required

INSTRUMENT	CRITICAL SPECIFICATIONS	USE	RECOMMENDED MODEL
DC Voltmeter	Range: ± 150 v Accuracy: $\pm 5\%$	Troubleshooting	-hp- Model 412A DC Voltmeter-Ohmmeter-Ammeter
DC Standard	Output: 100 v max Accuracy: $\pm 0.01\%$	Performance Checks	-hp- Model 740A DC Standard/Differential Voltmeter
Voltmeter Calibrator	AC: 3-300 v rms, 400 cps DC: 2-300 v	Troubleshooting	-hp- Model 738BR Voltmeter Calibrator
Digital Recorder	6 Column Print: 1-2-2-4 BCD Print Rate: 5 lines/sec	Performance Checks	-hp- Model 562A Digital Recorder
Thermal Converter	Input: 10 v Must be checked against known standard. Frequency response must be within $\pm 0.01\%$ from dc to 100 Kc.	Performance Checks Adjustment Procedures	See Figure 5-2
Oscillator	Frequency: 100 cps to 100 Kc Output: 9 v into rate load (600 Ω) Distortion: 0.1% or less	Performance Checks Adjustment Procedures	-hp- Model 200CD Audio Oscillator
Amplifier	Gain: 40 db Frequency: 100 cps to 100 Kc Distortion: 1% or less	Performance Checks Adjustment Procedures	McIntosh Model MI-200AB Power Amplifier
DC Null Voltmeter	Range: 100 μ v for null detector	Performance Checks Adjustment Procedures	-hp- Model 419A DC Null Voltmeter
Oscilloscope	Frequency: 50 cps to 100 Kc Vert. Sens: 0.05 v/cm Sweep: 5 ms/cm	Adjustment Procedure	-hp- Model 175A 2/1752A Plug-in and 10003A Probe
Electronic Counter	Period Measurement: 2.12 ms	Adjustment Procedure	-hp- Model 522B Electronic Counter
Bucking Supply (Figure 5-2)	500 Ω , 10 turns, 5%, 2 w 50 Ω , 23 turns, 10%, 1 w 1.34 v battery, mercury	Performance Checks Adjustment Procedure	-hp- Part No. 2100-0761 -hp- Part No. 2100-0716 -hp- Part No. 1420-0004
Resistive Divider (Figure 5-3)	8.88 K, 1%, 1 w 300 Ω , 23 turns, 10%, 1 w 1 K, 1%, 1 w	Performance Checks Adjustment Procedure	-hp- Part No. 0727-0151 -hp- Part No. 2100-0707 -hp- Part No. 0760-0002
Resistors	600 Ω , 1%, 1 w 10 K, 20 turns, 10% 10 M, variable, 30% 10 M, 1/4%, 2 w	Performance Checks Adjustment Procedure	-hp- Part No. 0727-0082 -hp- Part No. 2100-0888 -hp- Part No. 2100-0040 -hp- Part No. 0763-0014

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary for the proper maintenance of the -hp- Model 3445A AC/DC Range Unit. This section provides Performance Checks, Adjustment and Calibration Procedures and Troubleshooting Techniques required to accomplish the above objective.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table describes the type of instrument required, to include critical specifications, type of operation to be conducted, and the recommended model. If the specific model recommended is not available, equipment which meets or exceeds the critical specifications listed may be substituted.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front-panel procedures designed to compare the Model 3445A with its published specifications. These operations may be incorporated in periodic maintenance, post-repair, or incoming quality control checks. These operations should be completed before any attempt is made to adjust or calibrate the instrument. During these operations, the line voltage to the Model 3445A should be periodically varied $\pm 10\%$. A one-half hour warm-up period should be allowed prior to conducting these checks. Before any test of the Model 3445A is conducted, it must first be determined that the associated Model 3440A is operating within its published specifications. For proper test procedures, refer to Section V of the Model 3440A Operating and Service Manual.

5-7. DC CHECKS.

5-8. DC MANUAL OPERATIONS.

- A DC Standard (-hp- Model 740A) will be required for this test.

- Connect DC Standard OUTPUT to Model 3445A INPUT.
- Set Model 3445A FUNCTION to DC; RANGE to 10 V.
- Adjust Model 3440A ZERO control on rear panel for 0.000 reading, with polarity indicator alternating between + and -. Depress INT CHECK and adjust for 8000 reading.
- Adjust DC Standard to provide +9.0 vdc output.
- Model 3440A should read between 8.994 and 9.006 v.
- Test Model 3445A on 100 and 1000 v range positions using settings listed in Table 5-2.

Table 5-2. DC Accuracy Check

DC STANDARD -hp- MODEL 740A	MODEL 3445A RANGE	MODEL 3440A DISPLAY
009.00 v	10 V	8.994 to 9.006 v
010.50 v	10 V	0.500*
090.00 v	100 V	89.94 to 90.06 v
105.00 v	100 V	00.50*
900.00 v	1000 V	899.4 to 900.6 v
* OVERRANGE		

5-9. DC AUTO RANGING OPERATION.

- Figure 5-1 describes the test arrangement recommended. A DC Standard (-hp- Model 740A) and a variable resistor, 0 to 10 M ohms (-hp- 2100-0040) will be required.
- Set Model 3445A FUNCTION to DC; RANGE to AUTO.
- Adjust DC Standard for +10.00 v output.

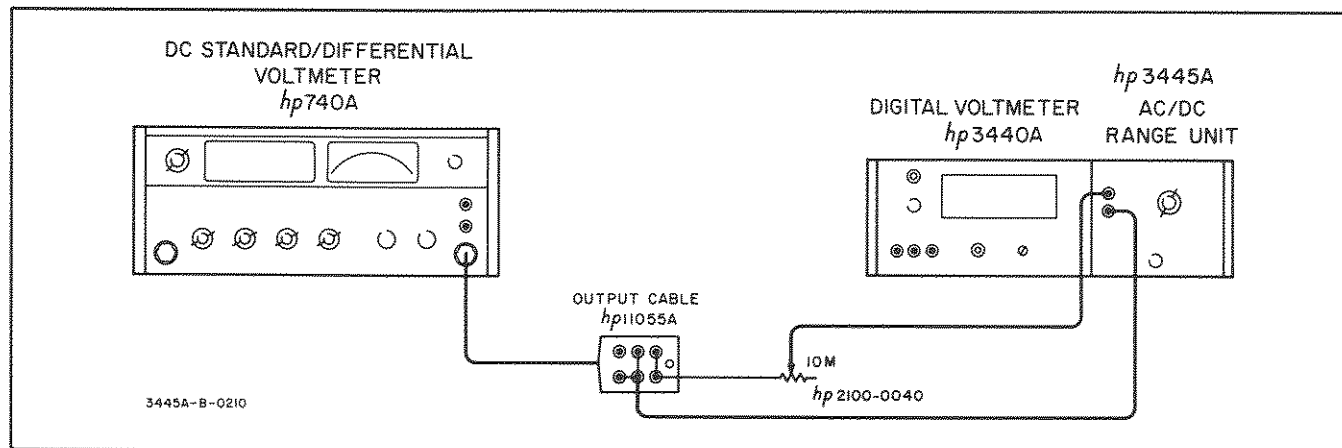


Figure 5-1. DC Accuracy Check

- d. With maximum external resistance in the circuit, Model 3440A should read approximately 5 v. Decrease external resistance slowly. Model 3445A should uprange at Model 3440A display of 10.00 v. As external resistance is increased, Model 3445A should downrange from 100 v to 10 v range between Model 3440A reading of 9.3 v and 9.0 v.
- e. Check upranging and downranging to and from 1000 v range using settings listed in Table 5-3. Model 3445A should range within limits specified.

5-10. DC RANGING SPEED.

- a. A DC Standard (-hp- Model 740A) will be required for the test.
- b. Adjust DC Standard for +300.0 vdc output. DO NOT CONNECT to Model 3445A Input.
- c. Set Model 3445A FUNCTION to DC; RANGE to AUTO.
- d. When DC Standard OUTPUT is plugged into Model 3445A INPUT, Model 3440A should display 99.95% of final value (or 299.8 v) within one sec.

5-11. DC INPUT RESISTANCE CHECK.

- a. Place a 10 M ohm resistor (-hp- Part No. 0763-0014) in series with the DC Standard OUTPUT and Model 3440A/3445A INPUT.
- b. Set Model 3440A/3445A FUNCTION to DC; RANGE to 10 V.
- c. Adjust DC Standard for 10.00 vdc output.
- d. Model 3440A/3445A should indicate approximately 5.05 v, corresponding to an input resistance of 10.2 M ohms, where:

$$R_{in} = \frac{E_{3440A}}{10 - E_{3440A}} \times 10 \times 10^6 \text{ ohm}$$

5-12. DC RECORDER OUTPUT CHECK.

- a. In addition to the test arrangement described in Paragraph 5-8, a Digital Recorder (-hp- Model 562A) will also be required.
- b. Connect Digital Recorder to DIGITAL RECORDER jack at rear of Model 3440A.
- c. Set Model 3445A FUNCTION to DC; RANGE to 10 V.
- d. Adjust DC Standard for 10.50 vdc output.
- e. Model 3440A should indicate 0.500 v OVER-RANGE.
- f. Digital Recorder should print a "3" in the Decimal Column, and a "9" in the Function Column indicating OVERRANGE.

NOTE

The Function Column will print a "7" if the Model 3440A/3445A and the Digital Recorder have been modified for a 1-2-4-8 Binary Coded Decimal (BCD) code.

- g. Rotate Model 3445A RANGE to AUTO.
- h. Adjust DC Standard for +2.00 vdc output.
- j. Set Model 3440A SAMPLE RATE for slow sample, but not to HOLD position.
- k. Readjust DC Standard for 20.00 vdc output. During next sample, Model 3440A should sample at maximum rate and immediately uprange to display +20.00 v.
- m. To check "print inhibit" circuit, observe to see that the Digital Recorder does not print during the ranging period.
- n. Table 5-4 contains additional settings and readings for further DIGITAL RECORDER checks.

Table 5-3. Auto Ranging Check

DC STANDARD OUTPUT	MODEL 3440A/3445A RANGE	MODEL 3440A DISPLAY AT UPRANGE	MODEL 3440A/3445A RANGE	MODEL 3440A DISPLAY AT DOWNRANGE
10 v	From 10 v to 100 v	10.00 v	From 100 v to 10 v	9.300 to 9.000 v
100 v	From 100 v to 1000 v	100.0 v	From 1000 v to 100 v	93.00 to 90.00 v

Table 5-4. Recorder Output Check

DC STANDARD OUTPUT	MODEL 3440A READINGS	DIGITAL RECORDER COLUMNS				
		FUNCTION	INPUT VOLTAGE			
		6	5	4	3	2
-200.0 v	-200.0 v	1	2	0	0	0
+21.11 v	+21.11 v	0	2	1	1	1
+2.222 v	+2.222 v	0	2	2	2	2

5-13. REMOTE CONTROL CHECK.

- Set Model 3445A RANGE to REMOTE; FUNCTION to either AC or DC.
- Model 3440A/3445A may be remotely upranged or downranged by grounding the appropriate pin on the REMOTE CONTROL jack (J4) located on the Model 3440A rear panel. Refer to Table 5-5 for appropriate pin required to obtain the range described.

Table 5-5. Remote Ranging

MODEL 3440A DISPLAY	J4 CONNECTION TO GROUND
0.000	J4, Pin 1
00.00	J4, Pin 2
000.0	When no pin is grounded, Model 3440A will al- ways return to 1000 v range.

5-14. AC OPERATIONS.

5-15. AC ACCURACY CHECK (10 V RANGE).

- Figure 5-2 describes the test arrangement recommended.
- Connect the Model 3440A/3445A as shown in Figure 5-2. Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- Set switch S1 to DC. Adjust dc standard for 9.0000 v output.

- Adjust "bucking supply" for null indication on null meter 10 μ v range. Once null is obtained, do not readjust "bucking supply."
- Reset switch S1 to AC.
- Set oscillator frequency to 100 cps; adjust output amplitude to restore null obtained in step d above. If necessary, utilize variable resistor across oscillator output to obtain null.
- The Model 3440A should display between 8.989 and 9.011 v.
- Repeat the above test using the oscillator frequencies listed in Table 5-6. At each frequency setting, it may be necessary to restore null indication by properly adjusting the oscillator output.

Table 5-6. AC Accuracy Check

MODEL 3445A RANGE	OSCILLATOR FREQUENCY	MODEL 3440A DISPLAY
10 V	100 cps	8.989 to 9.011 v
10 V	10 Kc	8.989 to 9.011 v
10 V	100 Kc	8.950 to 9.050 v
100 V	100 cps	89.89 to 90.11 v
100 V	10 Kc	89.89 to 90.11 v
100 V	100 Kc	89.50 to 90.50 v
1000 V	100 cps	99.7 to 100.3 v
1000 V	10 Kc	99.7 to 100.3 v
1000 V	100 Kc	96.8 to 103.2 v

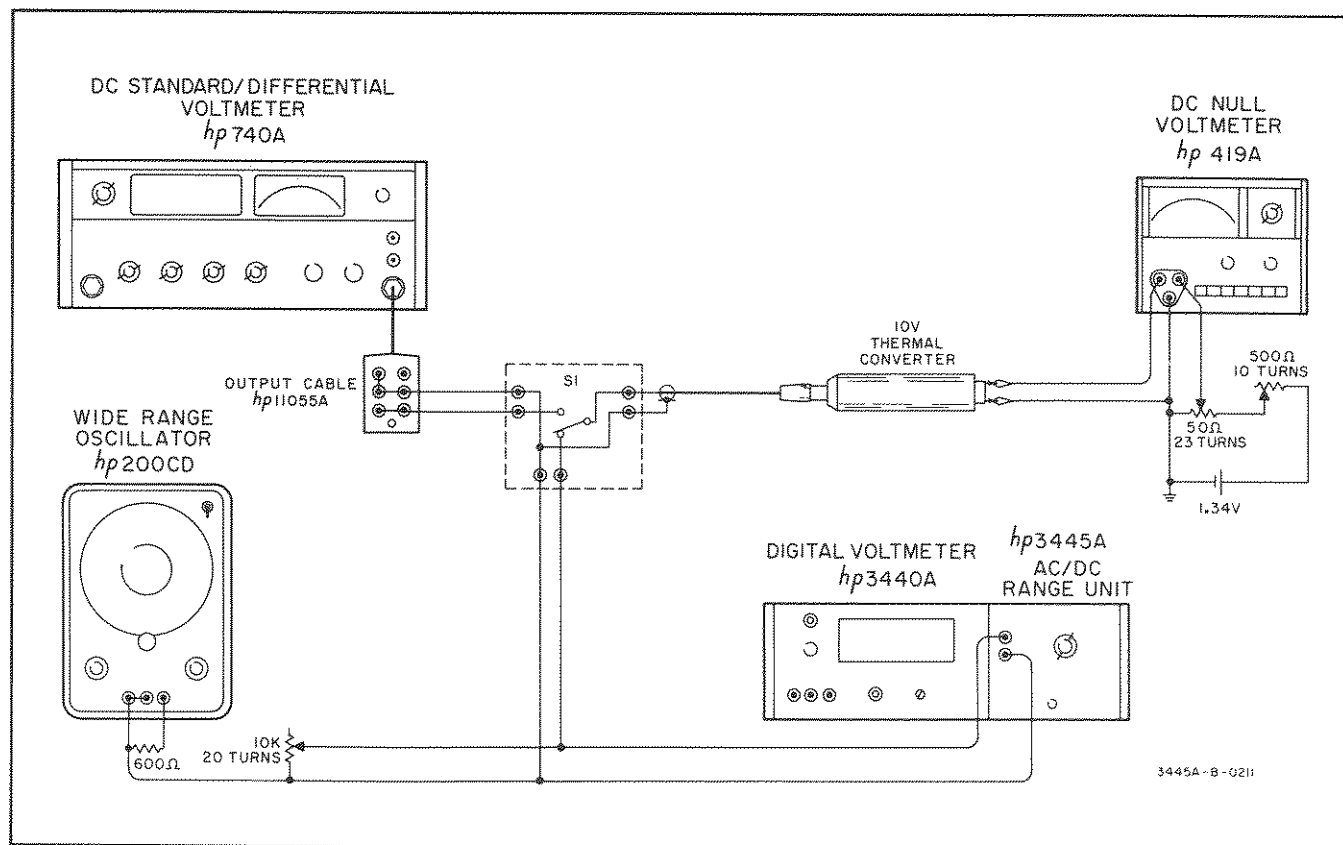


Figure 5-2. 10 V AC Accuracy Check

- j. If Model 3440A/3445A does not meet the specifications listed in Table 5-6, refer to Paragraph 5-24 for the proper calibration procedure.

5-16. AC ACCURACY CHECK (100 V RANGE).

- a. Figure 5-3 describes the test arrangement recommended.
- b. Connect the Model 3440A/3445A as shown in Figure 5-3. Set Model 3445A FUNCTION to DC; RANGE to 10 V. Connect INPUT to 10 v tap.
- c. Set switch S1 to DC. Adjust dc standard for 90.000 v output.
- d. Adjust R1 until Model 3440A displays 9.000 v. This will insure proper 10:1 division. Set Model 3445A RANGE to 100 V. Check for 90.00 v at 90 v tap.
- e. Set switch S1 to AC.
- f. Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- g. Connect Model 3445A INPUT to 9 v tap.
- h. Set oscillator frequency to 100 cps; adjust output amplitude for Model 3440A display of 9.000 v. This will insure a true 90.00 v across entire divider.

- j. Set Model 3445A RANGE to 100 V. Connect INPUT to 90 v tap.
- k. Model 3440A should display between 89.89 and 90.11 v.
- l. Repeat the above test using the frequencies listed in the second section of Table 5-6. At each frequency setting it will be necessary to reestablish the 90.00 v level as outlined in step h above.
- m. If Model 3440A/3445A does not meet the specifications listed in the second section of Table 5-6, refer to Paragraph 5-24 for the proper calibration procedure.

5-17. AC ACCURACY CHECK (1000 V RANGE).

- a. Figure 5-3 describes the test arrangement recommended.
- b. The procedure outlined in Paragraph 5-16 will be utilized to obtain ac calibration level of 100.0 v at the frequencies listed in the third section of Table 5-6. With the 100 V RANGE tested, and calibrated if necessary, it will be used to establish a proper 100 v level.
- c. If the Model 3440A/3445A does not meet the specifications listed in the third section of Table 5-6, refer to Paragraph 5-24 for the proper calibration procedure.

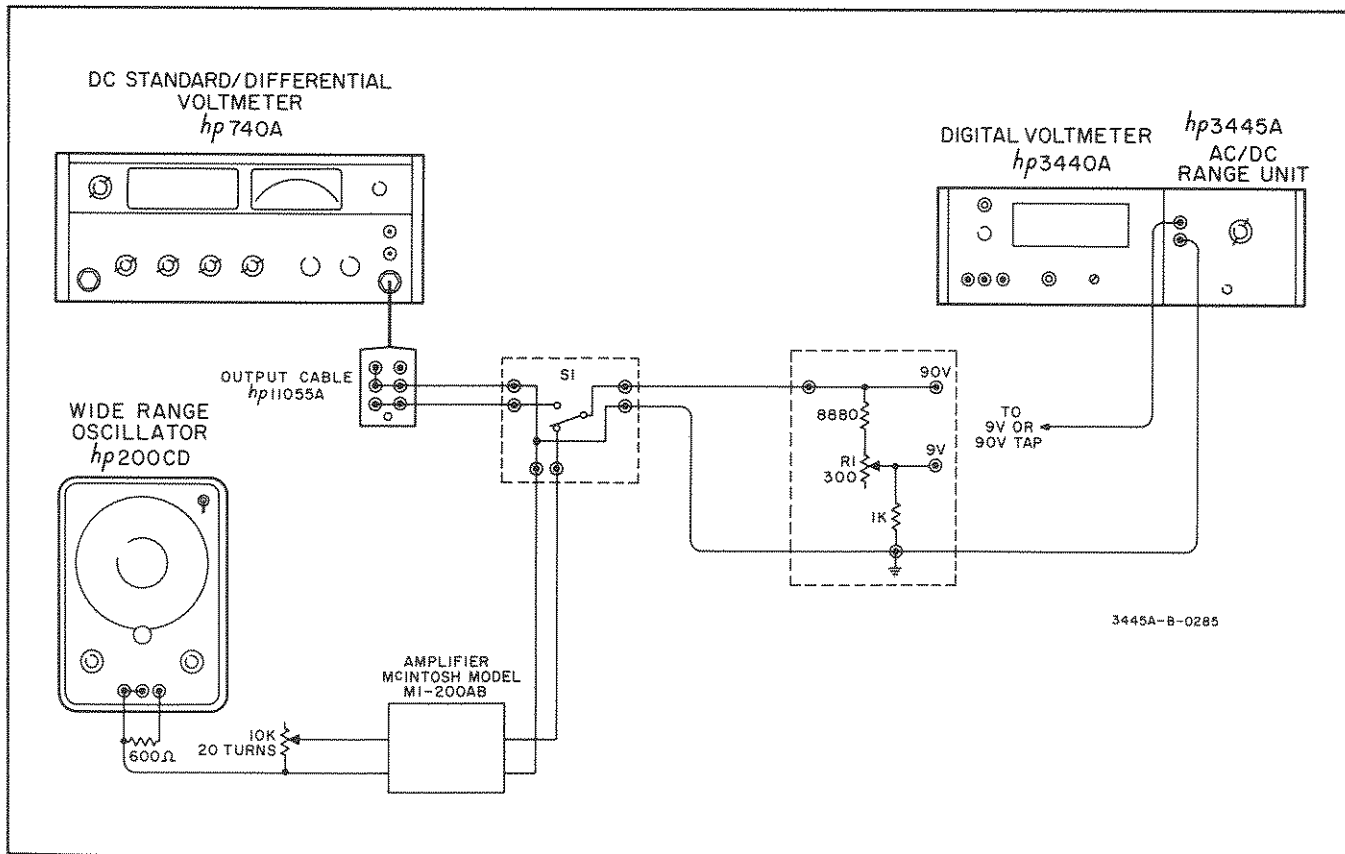


Figure 5-3. 100 V/1000 V AC Accuracy Check

5-18. AC INPUT IMPEDANCE CHECK.

- A Test Oscillator (-hp- Model 651A) and a 10 M ohm $\pm 1\%$, 1 watt resistor (-hp- Part No. 0763-0014) will be required for this test.
- Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- Connect oscillator output to Model 3445A INPUT. Set frequency to 100 cps; adjust output amplitude for Model 3440A display of 0.100 v.
- Disconnect oscillator, and place a 10 M ohm resistor in series with oscillator output and Model 3445A INPUT.
- Model 3440A/3445A should indicate approximately 0.050 v.
- Reset oscillator frequency to 10 Kc. Model 3440A/3445A should read not less than 0.010 v.
- Correct reading at e and f above will verify Model 3445A input impedance of 10 M ohms, shunted by 20 pf.

5-19. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-20. The following is a complete adjustment and calibration procedure for the Model 3445A, and should be performed only after it has previously been established that the Model 3445A is out of adjustment. Indiscriminate adjustment of internal controls to "refine" readings may actually cause more difficulties. If the following operations do not rectify any error which may exist, and all connections and procedures

have been rechecked, refer to Paragraph 5-28, Troubleshooting Techniques, for possible cause and recommended action. See Figure 5-5 for adjustment point location.

5-21. BIAS ADJUST.

- An Oscilloscope (-hp- Model 175A) and probe (-hp- Model 10003A) will be required for this operation.
- Set oscilloscope controls as follows:
POLARITY. +
AC/DC. DC
VERTICAL SENSITIVITY 2.0 v/cm
SWEEP MODE. Free Run
TRIGGER SOURCE INT
SWEEP TIME 5 ms/cm
- Short the Model 3445A INPUT terminals. Connect the oscilloscope to the collector of A4Q9 (TP1). Adjust VERTICAL control to position sweep at center of graticule.
- Turn the Model 3440A on, rotating the SAMPLE RATE control out of its CCW detent.
- Adjust A3R11 to return the sweep to the exact center of the graticule. Allow 5 seconds for transients to disappear.
- Reset VERTICAL SENSITIVITY control to 0.05 v/cm, and readjust A3R11 to position sweep approximately one cm below center of graticule.

5-22. HYSTERESIS ADJUST.

- Figure 5-4 describes the test arrangement recommended for this operation. An Elec-

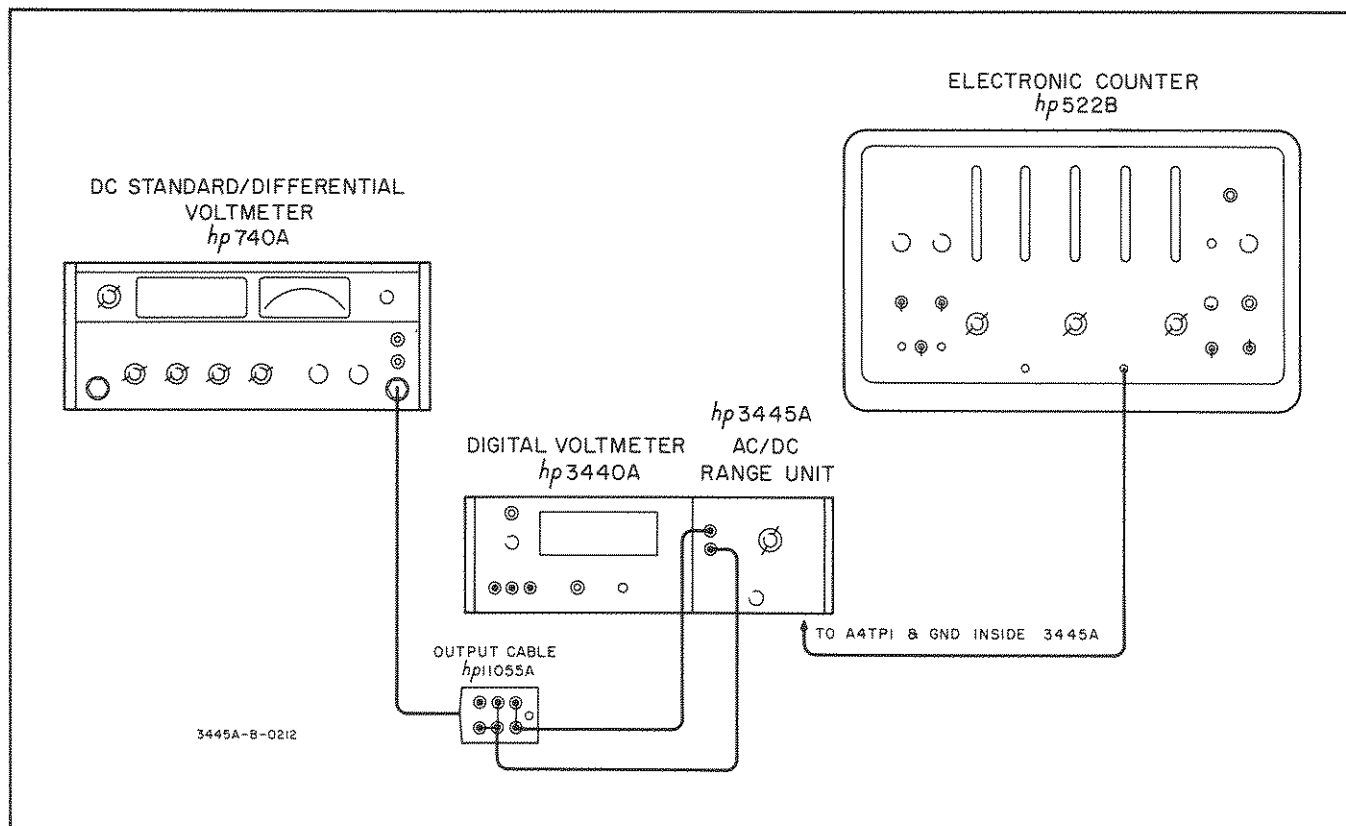


Figure 5-4. Hysteresis Adjustment

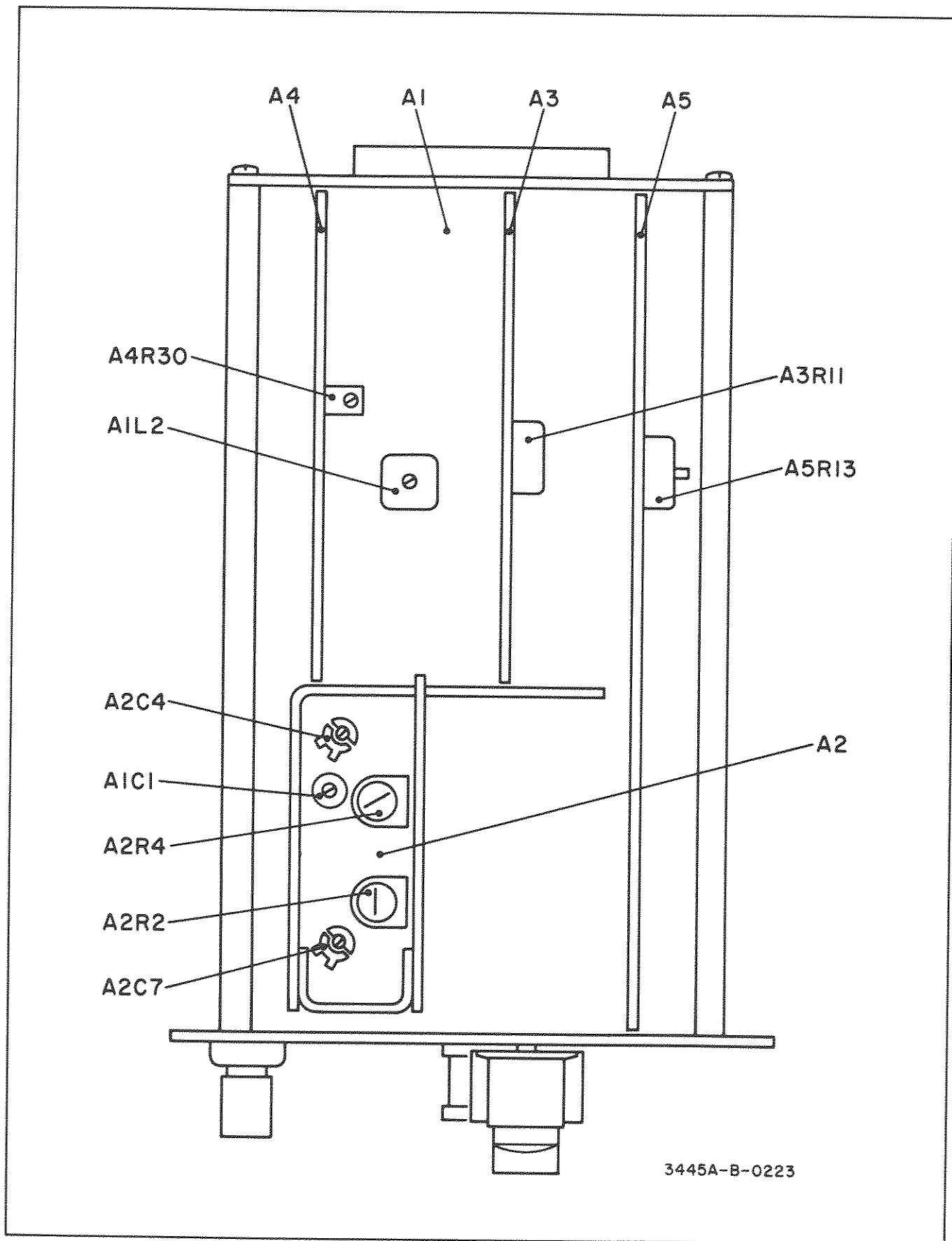


Figure 5-5. Model 3445A Adjustment Points

- tronic Counter (-hp- Model 522B) and a DC Standard (-hp- Model 740A) will be required.
- Connect the Model 3440A/3445A as shown in Figure 5-4.
 - Set Model 3445A FUNCTION to DC; RANGE to AUTO.
 - Adjust DC Standard for +1.0 v output.
 - Set counter controls as follows:

FUNCTION Selector	TIME INTER-
	VAL
TIME UNIT	MILLISEC
TRIGGER INPUT	COM.
TRIGGER SCOPE	START -
	STOP +
TRIGGER LEVEL VOLTS. .	START -5
	STOP -3
 - With counter connected to Model 3445A ground and A4TP1 (Hysteresis Multivibrator), adjust A5R13 for counter reading of 2.12 ms.

5-23. AC SCALE SHIFT ADJUST.

- Figure 5-2 describes the test arrangement recommended.
- Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- Using the procedure outlined in Paragraph 5-15, apply a 10 v, 100 cps signal to the Model 3445A INPUT.
- The Model 3440A should indicate 0.000 v OVERRRANGE (± 2 counts). If not, first insure that Model 3440A is properly zeroed, then if necessary, adjust A4R30 for proper display.
- To properly zero Model 3440A, set Model 3445A RANGE to 10 V; apply +8.000 v to INPUT. Set front panel INT CHECK 8000 to its mechanical mid-point. Adjust Model 3440A A3R51 (RAMP SLOPE) for +8.000 reading. INT CHECK 8000 may be used for fine adjustment.

5-24. AC CALIBRATION.

- Figures 5-2 and 5-3 describe the test arrangements recommended. The procedures outlined in Paragraphs 5-15 and 5-16 will be used to obtain calibration levels of 9 and 90 v at the frequencies specified.
- Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- Short Model 3445A INPUT terminals. Model 3440A should read 0.000 (one count may appear in last digit).
- Remove shorting device. Check Model 3440A zero as outlined in Paragraph 5-23 e above.
- Connect test arrangement as described in Figure 5-2.
- Using procedure outlined in Paragraph 5-15, apply a 9 v, 100 cps signal to the Model 3445A INPUT.

- Model 3440A should read 9.000 v (± 2 counts). If not, adjust A4R30 for proper display.
- Adjust oscillator frequency to 10 Kc. Insure that dc null did not drift. Model 3440A should read 9.000 v (± 2 counts). If not, adjust A1C1 for proper display.
- Adjust oscillator frequency to 100 Kc. Insure that dc null did not drift. Model 3440A should read 9.005 v (± 5 counts). If not, adjust A1L2 for proper display.
- Recheck 10 Kc and 100 cps settings as in steps g and h above.
- Set Model 3445A RANGE to 1000 V.
- Connect Model 3440A/3445A as shown in Figure 5-3. Using procedure outlined in Paragraph 5-16, apply 90 v, 100 cps signal to Model 3445A INPUT.
- Model 3440A should read 090.0 v (± 2 counts). If not, adjust A2R4 for proper display.
- Set oscillator frequency to 10 Kc. Insure that dc null did not drift. Model 3440A should read 090.0 v (± 2 counts). If not, center A2C4 and then adjust A2C11 for 090.0 v (± 2 counts) display. Then adjust A2C4 for 090.0 v (± 1 count) reading.
- Reset oscillator frequency to 100 cps. Insure that null did not drift.
- Model 3440A should read 090.0 v (± 2 counts). If not, adjust A2R4 for proper display.
- Reset oscillator frequency to 10 Kc. Insure that dc null did not drift. Model 3440A should read 090.0 v (± 2 counts). If not, adjust A2C4 for proper display.

5-25. SERVICING ETCHED CIRCUIT BOARDS.

5-26. The -hp- Model 3445A has four etched circuit boards. Use caution when removing them to avoid damaging mounted components. The assembly -hp- Part Number is silk screened on the exterior of the circuit board to identify it. Refer to Section VI for parts replacement and -hp- Part Number information.

5-27. The etched circuit boards are a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

- Use a low-heat (25 to 50 watts) small-tip soldering iron, and a small diameter rosin core solder.
- Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.
- Component lead holes should be cleaned before inserting new lead.

- d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.
- e. Clean excess flux from the connection and adjoining area.
- f. To avoid surface contamination of the printed circuit, clean with weak solution of Chlorothane Nu after repair. Rinse thoroughly with clean water. When completely dry, mask circuit board connector pins, and spray lightly with Krylon (#1302 or equivalent).

5-28. TROUBLESHOOTING TECHNIQUES.

5-29. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the instrument. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-19. An investigation should

also be made to insure that the trouble is not a result of conditions external to the Model 3445A, i. e., Model 3440A.

5-30. Conduct a visual check of the Model 3445A for possible burned or loose components, loose connections, or any other obvious condition which might suggest a source of trouble.

5-31. The following procedure is recommended for troubleshooting the Model 3445A:

- a. First, obtain as much information as possible concerning the malfunction from the front panel of the instrument, i. e. is the malfunction restricted to ac or dc operation, manual, AUTO or REMOTE ranges.
- b. Second, refer to Tables 5-7 and/or 5-8 to further isolate the malfunction to a particular functional area within the Model 3445A.
- c. Refer to Paragraphs 5-33 through 5-39 for additional troubleshooting techniques pertaining to that particular functional area defined in Tables 5-7 and/or 5-8.

Table 5-7. AC Malfunctions

MODE	MALFUNCTION DESCRIPTION	POSSIBLE CAUSE
MANUAL	3445A functions manually in all RANGE positions except 10 V RANGE.	Check A1K4.
	3445A functions manually in all RANGE positions except 100 V RANGE.	Check A2K2, A2C9, A2C10, A2R2 and A2R5.
	3445A functions manually in all RANGE positions except 1000 V RANGE.	Check A2K3, A2R4, A2C5, A2C6, A2C7 and A2R3.
AUTO	3445A will not uprange from any RANGE when in AUTO. OVER-RANGE does not flash.	Check 3440A OVERRANGE sensor; A4Q8 and A4Q9.
	3445A will not uprange from 10 V RANGE when in AUTO.	Check No. 1 Range Control Multi-vibrator (A5Q6 and A5Q7).
	3445A will not uprange from 100 V RANGE when in AUTO.	Check No. 2 Range Control Multi-vibrator (A5Q8 and A5Q9).
	Decimal point skips from 10 V RANGE to 1000 V RANGE when input exceeds ten volts. Reading correct.	Check A5CR16.
	3445A will not downrange from 1000 V RANGE when in AUTO. Functions in manual.	Check A5Q3, A5Q4, A5Q5, A5CR5, A5Q8 and A5Q9.
	3445A will not downrange from 100 V RANGE when in AUTO. Functions in manual.	Check A5Q3, A5Q4, A5Q5, A5CR5, A5Q6 and A5Q7.
	3445A downranges below 90 v rms on 1000 V RANGE or 9.0 v rms on the 100 V RANGE.	Check hysteresis control, A5R13. Refer to Paragraph 5-21.
	3445A downranges above 93 v rms on 1000 V RANGE or 9.3 v rms on 100 V RANGE.	Check hysteresis control, A5R13. Refer to Paragraph 5-21.

Table 5-8. DC Malfunctions

MODE	MALFUNCTION DESCRIPTION	POSSIBLE CAUSE
MANUAL	3445A functions manually in all RANGE positions except 10 V. 3445A functions manually in all RANGE positions except 100 V. 3445A functions manually in all RANGE positions except 1000 V.	Check A1K1 and 3440A Input Attenuator. Check A2K2 and 3440A Input Attenuator. Check A3K3 and 3440A Input Attenuator.
AUTO	3445A will not uprange from any RANGE when in AUTO OVERRANGE does not flash. 3445A will not uprange from 10 V RANGE. OVERRANGE flashing. 3445A will not uprange from 100 V RANGE. OVERRANGE flashing. Decimal point skips from 10 V RANGE to 1000 V RANGE when input exceeds ten volts. Reading correct. 3445A will not downrange from 1000 V RANGE when in AUTO. Functions in manual. 3445A downranges below 90 v rms on 1000 V RANGE or 9.0 v rms on the 10 V RANGE. 3445A downranges above 93 v rms on the 1000 V RANGE or 9.3 v rms on the 10 V RANGE.	Check 3440A OVERRANGE sensor, A4Q8 and A4Q9. Check No. 1 Range Control Multivibrator, A5Q6 and A5Q7. Check No. 2 Range Control Multivibrator, A5Q6 and A5Q7. Check A5CR16. Check A5Q3, A5Q4, A5Q5, A5CR5, A5Q6 and A5Q7. Check hysteresis control, A5R13. Refer to Paragraph 5-21. Check hysteresis control, A5R13. Refer to Paragraph 5-21.
GENERAL	3445A samples at maximum rate. SAMPLE RATE control has no effect. Readout display and manual are normal. 3445A functions in AC only. Manual and AUTO. 3445A does not control recorder print command. 3445A prints while ranging. Left and center decimal appear simultaneously on 10 V and 100 V RANGE positions. Reading correct. Left decimal does not appear on 10 V RANGE. Reading correct. 3445A functions in DC only. 3445A samples at maximum rate. SAMPLE RATE control has no effect. Readout display and manual mode normal. 3445A does not control recorder print command. 3445A prints while ranging. Left and center decimal appear simultaneously in either 10 V or 100 V RANGE positions. Reading correct. Left decimal does not appear on 10 V RANGE. Reading correct. Center decimal does not appear on 100 V RANGE. Reading correct.	Check Inhibit Multivibrator, A5Q12 and A5Q13; speed-up amplifier A1Q2. Check 3440A Input Attenuator. Check Inhibit Multivibrator, A5Q12 and A5Q13. Check A3Q3, A3Q4, A3Q5 and A3Q6. Check A3Q4. Check amplifier, A4Q1 through A4Q8, A1C1, A1C2 and A1R17. Check Inhibit Multivibrator, A5Q12 and A5Q13; speed-up amplifier A1Q2. Check Inhibit Multivibrator, A5Q12 and A5Q13. Check A2K2. Check A3Q4. Check A3Q5.

5-32. The techniques outlined in Paragraphs 5-33 through 5-39 are not designed to measure all circuit parameters within the functional area concerned, rather, only to localize the malfunction. Therefore, it is quite possible that additional measurements may be required to completely isolate the faulty component. Amplifier gain may also vary slightly between instruments; therefore, it should not be necessary to precisely duplicate waveforms or voltages described.

5-33. AC TO DC CONVERTER (AC OPERATIONS).

- a. Set Model 3445A FUNCTION to AC; RANGE to 10 V.
- b. Apply a 10 v, 400 cps signal to the Model 3445A INPUT.
- c. Dc voltage at pin 46, P6 should be approximately 9.8 v rms.
- d. Ac voltage at A4TP1 should be approximately 25 v rms.
- e. Ac voltage at Pin 20, A4 should be approximately 2.3 v rms (ac feedback).
- f. Ac voltage at A4TP2 should be approximately 15 mv rms; at A4TP3 approximately 55 mv rms.

5-34. RELAY CHECKS.

- a. Set Model 3445A FUNCTION to DC; RANGE to 10 V.
- b. Connect Voltmeter Calibrator (-hp- Model 738BR) OUTPUT to Model 3445A INPUT. Apply a +10 vdc signal to Model 3445A.
- c. A1K1 - With a DC Voltmeter (-hp- Model 412A), measure the dc voltage at both ends of A1K1, referenced to ground. Both readings should be approximately +10 v.
- d. A2K2 - Set Model 3445A FUNCTION to DC; RANGE to 100 V. Measure dc voltage at both ends of A2K2, referenced to ground. Both readings should be approximately +1 v.
- e. A2K3 - Set Model 3445A FUNCTION to DC; RANGE to 100 V. Measure dc voltage at both ends of A2K3, referenced to ground. Both readings should be approximately +100 mv.
- f. A1K4 - Set Model 3445A FUNCTION to AC; RANGE to 10 V. Adjust Voltmeter Calibrator to provide a 10 v, 400 cps signal to the Model 3445A INPUT. Connect an Oscilloscope (-hp- Model 175A) between A4TP1 and ground. Trace should indicate a sine wave whose peak voltage is approximately 32 v (23 v rms). Switch Model 3445A FUNCTION to DC; sine wave amplitude should decrease to approximately 20 v peak (14 v rms).

5-35. POWER SUPPLY CHECK.

- a. A DC Voltmeter (-hp- Model 412A) will be required for this test.
- b. Remove the Model 3445A from the main frame.

- c. Rotate Model 3440A SAMPLE RATE out of its CCW detent (ON position).
- d. Set DC Voltmeter RANGE to 300 V; FUNCTION to VOLTS.
- e. Connect DC Voltmeter between Model 3440A chassis ground and Pin 23, J6. DC Voltmeter should read -150 vdc (± 15 v).
- f. Connect DC Voltmeter to Pin 30, J6. DC Voltmeter should read +150 vdc (± 15 v).
- g. Set DC Voltmeter RANGE to 100 V. Voltage at Pin 41, J6 should not be more positive than -35 v.
- h. Dc voltage at base of A3Q9 should be +82 vdc (± 5 v); and at the base of A3Q8, -82 vdc (± 5 v).
- j. Set DC Voltmeter RANGE to 30 V. Voltage at Pin 17, J6 should not be less than +12 v (nominally +12 to +13 vdc).

5-36. RANGING CIRCUIT TEST.

5-37. UPRANGING.

- a. Set Model 3445A FUNCTION to AC; RANGE to AUTO.
- b. Connect Voltmeter Calibrator (-hp- Model 738BR) OUTPUT to Model 3445A INPUT. Adjust Voltmeter Calibrator for a 3 v rms, 400 cps output signal.
- c. Connect DC Voltmeter (-hp- Model 412A) between Pin 4, A5 and chassis. Voltmeter should read approximately -32 v. When the input voltage is increased and Model 3445A upranges, the voltmeter should dip to approximately -12 v, and then immediately return to original deflection.
- d. Adjust Voltmeter Calibrator for 30 v rms output. As Model 3445A upranges, DC Voltmeter reading should dip to approximately -12 v, and then immediately return to original deflection.
- e. Adjust Voltmeter Calibrator (-hp- Model 738BR) for 300 v rms output. As Model 3445A upranges, DC Voltmeter reading should dip to approximately -12 v, and then immediately return to original deflection. Transient indicated by dip in DC Voltmeter reading verifies presence of overrange pulse.
- f. Check No. 1 and No. 2 Range Control Multivibrators, A5Q6, A5Q7, A5Q8, and A5Q9. Refer to Table 5-9 for corresponding voltage values.

Table 5-9. Range Control Multivibrator Check

RANGE	RELAYS		TRANSISTOR COLLECTOR VOLTAGES			
	AC	DC	A5Q6	A5Q7	A5Q8	A5Q9
10 v	A1K4	A1K1	-30 v	-2.5 v	-4 v	-32 v
100 v	A2K2	A2K2	-1.5 v	-34 v	-2.5 v	-34 v
1000 v	A3K3	A3K3	-1.5 v	-34 v	-34 v	-2.5 v

- g. Check relays as outlined in Paragraph 5-34.
- h. With no input applied to the Model 3445A, connect DC Voltmeter to Pin 21, A3. Set Model 3445A FUNCTION to DC; RANGE to 10 V (left decimal). DC Voltmeter should read approximately -5 v. If not, check A3Q4. Remove DC Voltmeter. Set Model 3445A RANGE to 100 V (center decimal). Connect DC Voltmeter to Pin 22, A3. DC Voltmeter should read -5 v. If not, check A3Q5.

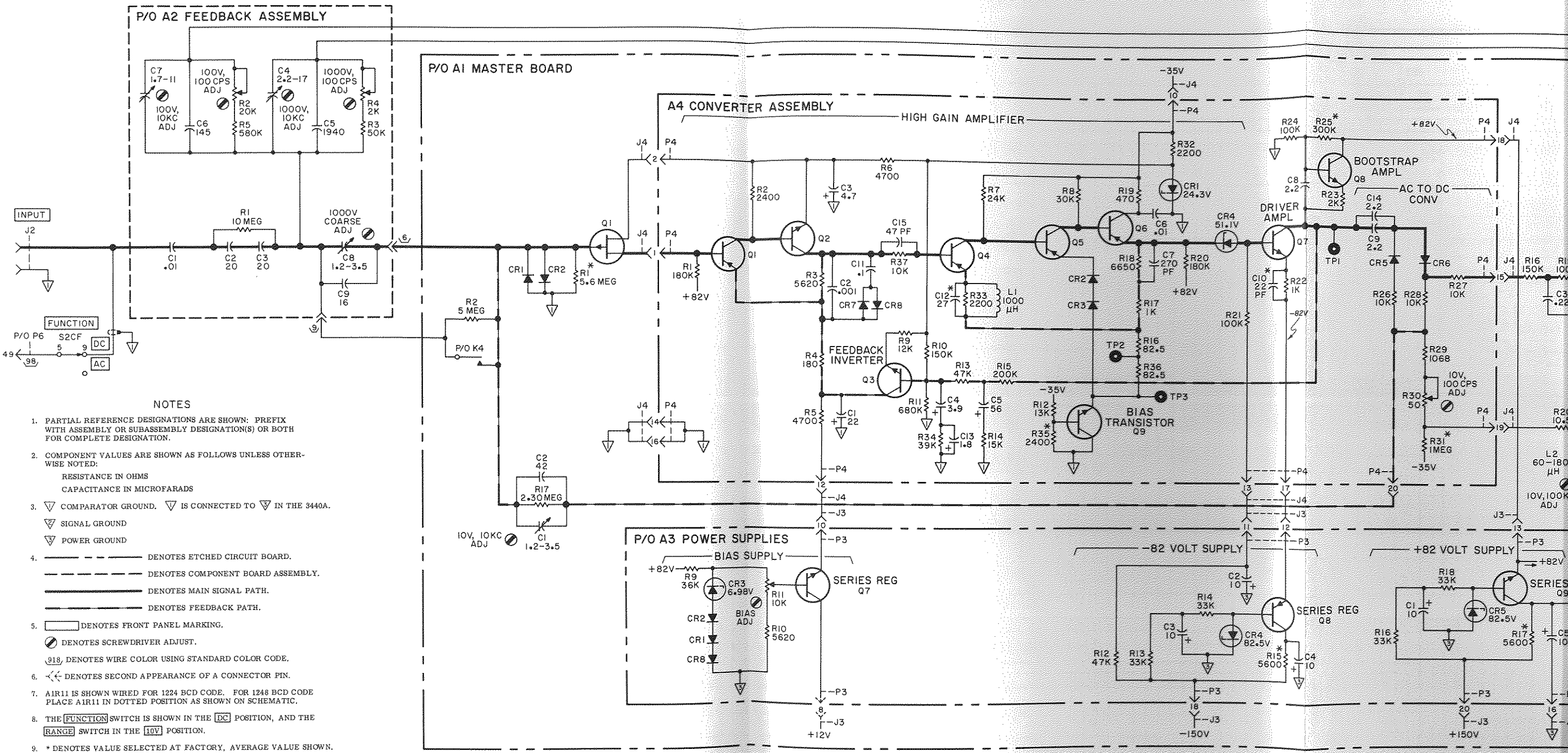
5-38. DOWNRANGING.

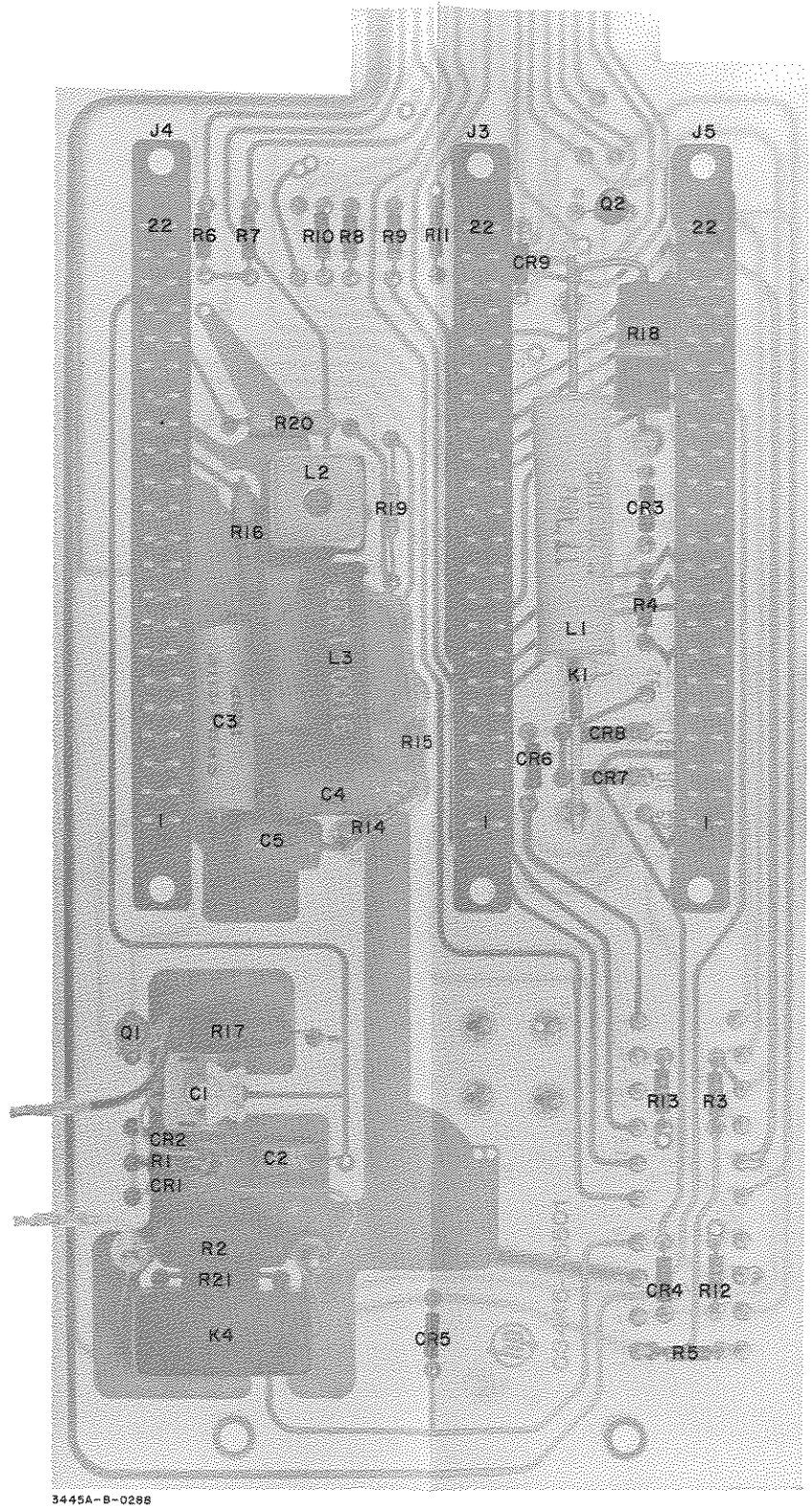
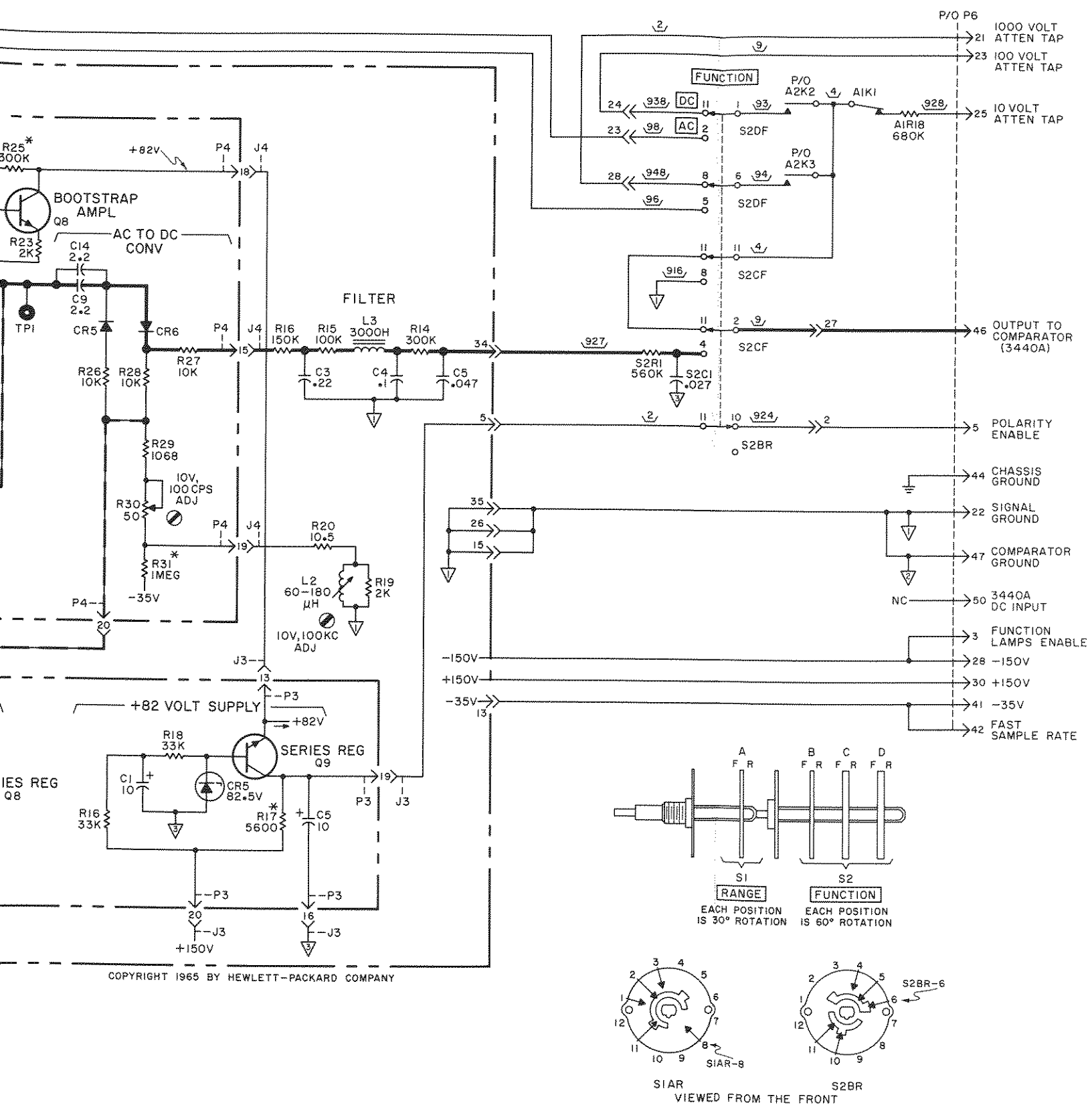
- a. Set Model 3445A FUNCTION to AC; RANGE to AUTO.
- b. Connect Voltmeter Calibrator OUTPUT to Model 3445A INPUT. Adjust Voltmeter Calibrator for 300 v rms, 400 cps output signal.
- c. Connect DC Voltmeter to Pin 18, A5. DC Voltmeter should read approximately -0.21 v.
- d. Adjust Voltmeter Calibrator output to 30 v rms. DC Voltmeter reading should dip to zero, then immediately return to original deflection. Adjust Voltmeter Calibrator output to 3 v rms. DC Voltmeter should once again dip to zero, then immediately return to original deflection.

- e. This test may also be conducted using dc input voltages. Appearance of transient verifies presence of downrange pulse.
- f. Check Hysteresis Multivibrator, A5Q1 and A5Q2.
- g. Check Downrange Control Multivibrator, A5Q4 and A5Q5.
- h. Check A5CR6 and A5CR17.
- j. Check No. 1 and No. 2 Range Control Multivibrators, A5Q6, A5Q7, A5Q8 and A5Q9. Refer to Table 5-9 for transistor voltage values.

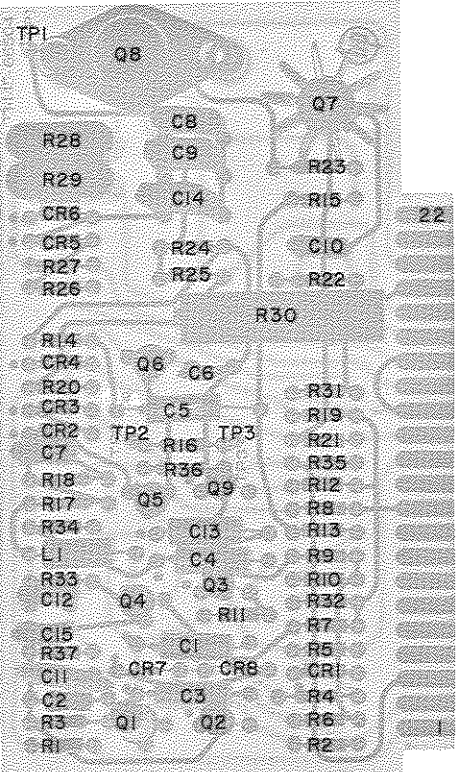
5-39. DECIMAL CHECKS.

- a. Set Model 3445A FUNCTION to AC; RANGE to 10 V (corresponds to left decimal).
- b. Connect DC Voltmeter (-hp- Model 412A) to Pin 21, A3. DC Voltmeter should read 5 v. If not, check A3Q5. Disconnect DC Voltmeter.
- c. Set Model 3445A RANGE to 100 V (corresponds to center decimal).
- d. Connect DC Voltmeter to Pin 22, A3. DC Voltmeter should read -5 v. If not, check A3Q5.

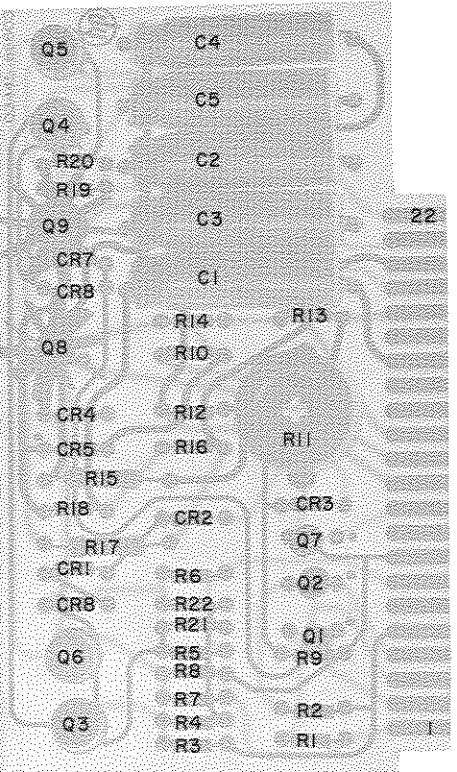




A1 MASTER BOARD

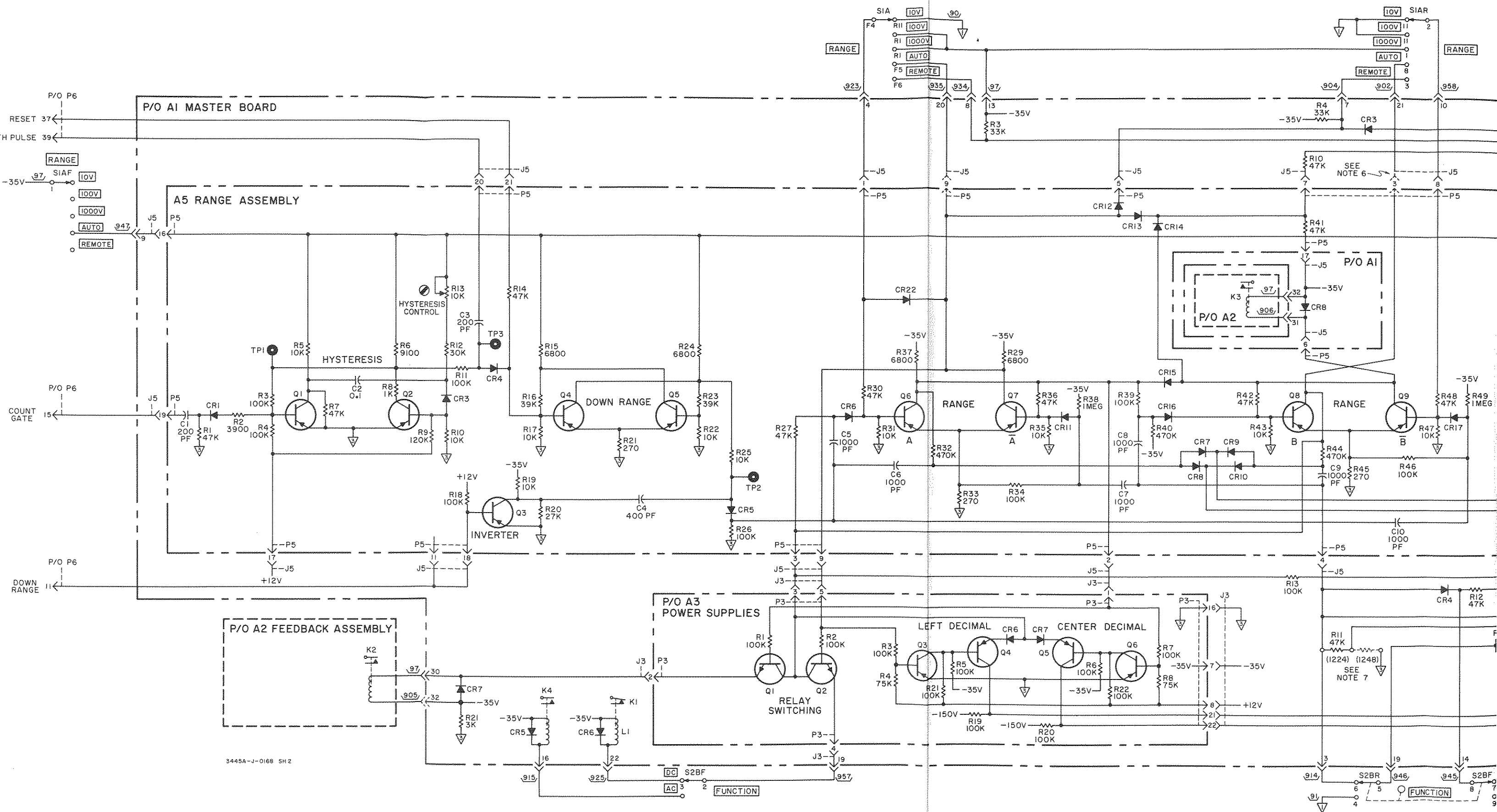


A4 CONVERTER ASSEMBLY



A3 POWER SUPPLIES

Figure 5-6. AC Converter Schematic and A1, A3, A4 Location of Components



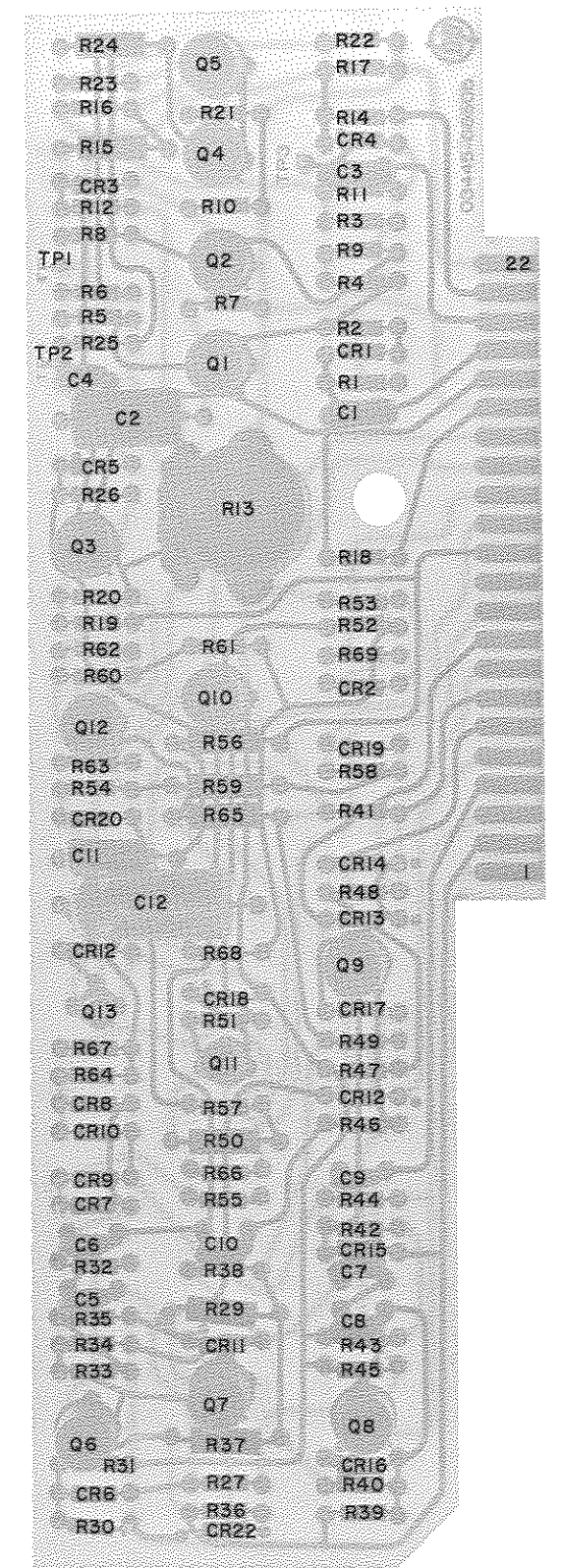
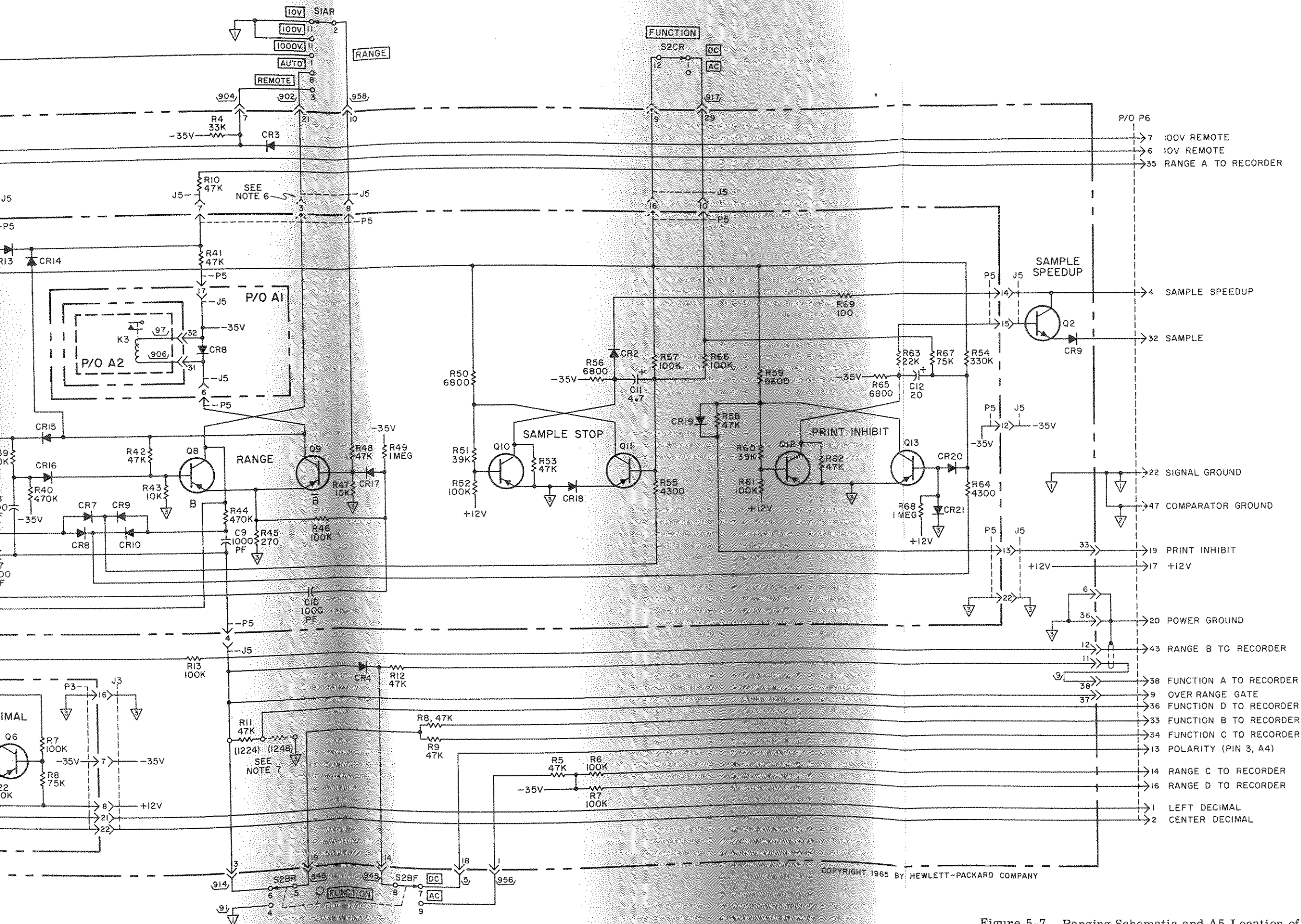


Figure 5-7. Ranging Schematic and A5 Location of Components

NOTES

NOTES

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphabetic order of their reference designators and indicates the description and -hp- part number of each part, together with any applicable notes. Table 6-2 lists parts in alphabetic order of their -hp- part number and provides the following information on each part:

- a. Description of the part (see list of abbreviations below).
- b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
- c. Manufacturer's part number.
- d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.

REFERENCE DESIGNATORS

A = assembly	F = fuse	P = plug	V = vacuum tube, neon bulb, photocell, etc.
B = motor	FL = filter	Q = transistor	W = cable
C = capacitor	J = jack	R = resistor	X = socket
CR = diode	K = relay	RT = thermistor	XF = fuseholder
DL = delay line	L = inductor	S = switch	XDS = lampholder
DS = device signaling (lamp)	M = meter	T = transformer	Z = network
E = misc electronic part	MP = mechanical part		

ABBREVIATIONS

a = amperes	elect = electrolytic	mtg = mounting	rot = rotary
bp = bandpass	encap = encapsulated	my = mylar	rms = root-mean-square
bwo = backward wave oscillator	f = farads	NC = normally closed	rmo = rack mount only
c = carbon	fxd = fixed	Ne = neon	s-b = slow-blow
cer = ceramic	Ge = germanium	NO = normally open	Se = selenium
cmo = cabinet mount only	grd = ground (ed)	NPO = negative positive zero (zero temperature coefficient)	sect = section(s)
coef = coefficient	h = henries	nsr = not separately replaceable	Si = silicon
com = common	Hg = mercury	obd = order by description	sil = silver
comp = composition	imp = impregnated	p = peak	sl = slide
conn = connection	inca = incandescent	pc = printed circuit board	td = time delay
crt = cathode-ray tube	ins = insulation (ed)	pf = picofarads = 10^{-12} farads	TiO ₂ = titanium dioxide
dep = deposited	K = kilo = 1000	pp = peak to peak	tog = toggle
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by stock numbers.	lin = linear taper	piv = peak inverse voltage	tol = tolerance
	log = logarithmic taper	pos = position (s)	trim = trimmer
	m = milli = 10^{-3}	pot = potentiometer	twt = traveling wave tube
	M = megohms	rect = rectifier	var = variable
	ma = milliamperes		w/ = with
	μ = micro = 10^{-6}		W = watts
	minat = miniature		ww = wirewound
	mfgl = metal film on glass		w/o = without
	mfr = manufacturer		* = optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Reference Designation Index

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A1	03445-66501	Board assembly: master	
A1C1	0121-0131	C: var, air die, 1.2 - 3.5 pf	
A1C2	p/o 0160-2008	C: fxd, 42 pf	
A1C3	0170-0038	C: fxd, my die, 0.22 μ f $\pm$ 10%, 200 vdcw	
A1C4	0160-0168	C: fxd, 0.1 μ f $\pm$ 10%, 200 vdcw	
A1C5	0170-0040	C: fxd, my die, 0.047 μ f $\pm$ 10%	
A1CR1 and A1CR2	1901-0027	Diode: Si, 2 ma at +1 v, 15 piv, 0.5 ns	
A1CR3 thru A1CR9	1901-0025	Diode: Si, 100 ma at +1 v, 100 piv, 12 pf	
A1J3 thru A1J5	1251-0465	Connector: printed circuit, 22 tuning fork type contacts	
A1K1	0490-0049	Relay: reed, SPST normally open	
A1K2 and A1K3		Not Assigned	
A1K4	0490-0158	Relay: reed, 1.5 pf, coil, contact	
A1L1	9161-0013	Coil: electromagnetic, for single reed switch	
A1L2	9100-1307	Inductor: var, printed circuit mounting, 60 - 180 μ h	
A1L3	9100-1308	Inductor: fxd, printed circuit mounting	
A1Q1	1855-0004	Transistor: P channel	
A1Q2	1854-0033	Transistor: 2N3391, NPN Si	
A1R1	0683-5655	R: fxd, comp, 5.6 meg $\pm$ 5%, 1/4 w	
A1R2	p/o 0698-3308	R: fxd, met flm, 5 meg $\pm$ 0.5%, 1/2 w	
A1R3 and A1R4	0683-3335	R: fxd, comp, 33 K $\pm$ 5%, 1/4 w	
A1R5	0683-4735	R: fxd, comp, 47 K $\pm$ 5%, 1/4 w	
A1R6 and A1R7	0683-1045	R: fxd, comp, 100 K $\pm$ 5%, 1/4 w	
A1R8 thru A1R12	0683-4735	R: fxd, comp, 47 K $\pm$ 5%, 1/4 w	
A1R13	0683-1045	R: fxd, comp, 100 K $\pm$ 5%, 1/4 w	
A1R14	0683-3045	R: fxd, comp, 300 K $\pm$ 5%, 1/4 w	
A1R15	0683-1045	R: fxd, comp, 100 K $\pm$ 5%, 1/4 w	
A1R16	0757-0352	R: fxd, met flm, 150 K $\pm$ 1%, 1/2 w	
A1R17	p/o 0698-3308	R: fxd, met flm, 2.3 meg $\pm$ 0.5%, 1/4 w	
A1R18	0692-6845	R: fxd, comp, 680 K $\pm$ 5%, 2 w	
A1R19	0757-0283	R: fxd, met flm, 2000 ohms $\pm$ 1%, 1/8 w	
A1R20	0727-0955	R: fxd, carb flm, 10.5 ohms $\pm$ 1%, 1/2 w	
A1R21	0686-3025	R: fxd, comp, 3000 ohms $\pm$ 5%, 1/2 w	
A2	03445-61201	Feedback assembly	
A2C1	0160-0996	C: fxd, disc cer, 0.01 μ f $\pm$ 20%, 2000 vdcw	
A2C2 and A2C3	p/o 0160-2008	C: fxd, 20 pf	
A2C4	0121-0116	C: var, air die, 2.2 - 17 pf	
A2C5	p/o 0160-2008	C: fxd, 1940 pf	
A2C6	p/o 0160-2008	C: fxd, 145 pf	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2C7 A2C8 A2C9	0121-0127 0121-0131 p/o 0160-2008	C: var, air die, 1.7 - 11 pf C: var, air die, 1.2 - 3.5 pf C: fxd, 16 pf	
A2K1 A2K2 and A2K3	0490-0158	Not Assigned Relay: reed, 1.5 pf, coil, contact	
A2R1 A2R2 A2R3 A2R4 A2R5	p/o 0698-3308 2100-1437 p/o 0698-3308 2100-1523 p/o 0698-3308	R: fxd, met flm, 10 meg $\pm 0.5\%$ R: var, prec ww, 20 K $\pm 5\%$, 1 w R: fxd, 50 K $\pm 0.5\%$ R: var, prec ww, 2 K $\pm 5\%$, 1 w R: fxd, 580 K $\pm 0.5\%$	
A3	03445-66503	Board assembly: power supply	
A3C1 thru A3C5	0180-0089	C: fxd, elect, 10 μ f $\pm 100\%$ -10%, 150 vdcw	
A3CR1 and A3CR2	1901-0025	Diode: Si, 100 ma at +1 v, 100 piv, 12 pf	
A3CR3	1902-3124	Diode: Si, breakdown voltage 6.98 v $\pm 5\%$, 400 mw	
A3CR4 and A3CR5	1902-3404	Diode: Si, breakdown voltage 82.5 $\pm 5\%$, 400 mw	
A3CR6 thru A3CR8	1901-0025	Diode: Si, 100 ma at ± 1 v, 100 piv, 12 pf	
A3Q1 and A3Q2	1854-0033	Transistor: 2N3391, NPN Si	
A3Q3	1850-0062	Transistor: special 2N404, germanium alloy junction	
A3Q4 and A3Q5	1850-0128	Transistor: 2N398B, PNP germanium	
A3Q6	1850-0062	Transistor: special 2N404, germanium alloy junction	
A3Q7	1854-0033	Transistor: 2N3391, NPN Si	
A3Q8	1853-0007 1205-0018	Transistor: 2N3251, PNP, Si Heat sink: semiconductor for T0-18 for A3Q8	
A3Q9	1854-0039 1250-0033	Transistor: 2N3053, NPN Si Heat sink: semiconductor for T0-5 for A3Q9	
A3R1 thru A3R3	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A3R4	0683-7535	R: fxd, comp, 75 K $\pm 5\%$, 1/4 w	
A3R5 thru A3R7	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A3R8	0683-7535	R: fxd, comp, 75 K $\pm 5\%$, 1/4 w	
A3R9	0683-3635	R: fxd, comp, 36 K $\pm 5\%$, 1/4 w	
A3R10	0757-0200	R: fxd, met flm, 5.62 K $\pm 1\%$, 1/8 w	
A3R11	2100-0396	R: var, ww, 10 K $\pm 20\%$, 1 1/2 w	
A3R12	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A3R13 and A3R14	0683-3335	R: fxd, comp, 33 K $\pm 5\%$, 1/4 w	
A3R15	0757-0834	R: fxd, met flm, 5.62 K $\pm 1\%$, 1/2 w	
A3R16	0683-3335	R: fxd, comp, 33 K $\pm 5\%$, 1/4 w	
A3R17	0757-0834	R: fxd, met flm, 5.62 K $\pm 1\%$, 1/4 w	
A3R18	0683-3335	R: fxd, comp, 33 K $\pm 5\%$, 1/4 w	
A3R19 thru A3R22	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A4	03445-66504	Board assembly: converter	
A4C1	0180-0228	C: fxd, tanta elect, 22 μ f $\pm$ 10%, 10 vdcw	
A4C2	0160-0153	C: fxd, 0.001 μ f $\pm$ 10%,	
A4C3	0180-0100	C: fxd, solid tanta die, 4.7 μ f $\pm$ 10%, 35 vdcw	
A4C4	0180-0022	C: fxd, solid tanta elect, 3.9 μ f $\pm$ 10%, 35 vdcw	
A4C5	0180-0196	C: fxd, tanta elect, 56 μ f $\pm$ 10%, 15 vdcw	
A4C6	0150-0093	C: fxd, 0.01 μ f $\pm$ 80% -20%, 100 vdcw	
A4C7	0140-0206	C: fxd, dipped mica, 270 pf $\pm$ 5%	
A4C8 and A4C9	0160-0128	C: fxd, cer die, 2.2 μ f $\pm$ 20%, 25 vdcw	
A4C10*	0140-0145	C: fxd, dipped mica, 22 pf $\pm$ 5%	
A4C11	0150-0084	C: fxd, cer die, 0.1 μ f $\pm$ 80% -20%, 50 vdcw	
A4C12*	0160-0178	C: fxd, mica die, 27 pf $\pm$ 5%, 300 vdcw	
A4C13	0180-0101	C: fxd, solid tanta die, 1.8 μ f $\pm$ 10%, 35 vdcw	
A4C14	0160-0128	C: fxd, cer die, 2.2 μ f $\pm$ 20%, 25 vdcw	
A4C15	0140-0204	C: fxd, dipped mica, 47 pf $\pm$ 5%	
A4CR1	1902-3259	Diode: Si, breakdown voltage 24.3 v $\pm$ 5%, 400 mw	
A4CR2 and A4CR3	1901-0025	Diode: Si, 100 ma at +1 v, 100 piv, 12 pf	
A4CR4	1902-3345	Diode: Si, breakdown voltage 51.1 v $\pm$ 5%, 400 mw	
A4CR5 and A4CR6	1901-0050	Diode: Si, 200 ma at 1 v, 12 pf 2 ns, 75 v working	
A4CR7 and A4CR8	1901-0040	Diode: Si, 30 ma at + 1 v, 30 piv, 2 pf, 2 ns	
A4L1	9140-0137	Coil: fxd, RF, electromagnetic, 1000 μ h $\pm$ 5%	
A4Q1	1850-0096	Transistor: 2N2189, PNP germanium	
A4Q2 and A4Q3	1854-0033	Transistor: 2N3391, NPN Si	
A4Q4 and A4Q5	1853-0009	Transistor: PNP Si	
A4Q6	1853-0010	Transistor: PNP Si	
A4Q7	1854-0069	Transistor: NPN Si	
	1205-0033	Heat sink for A4Q7	
A4Q8	1854-0068	Transistor: NPN Si	
A4Q9	1854-0033	Transistor: 2N3391, NPN Si	
A4R1	0683-1845	R: fxd, comp, 180 K $\pm$ 5%, 1/4 w	
A4R2	0683-2425	R: fxd, comp, 2400 ohms $\pm$ 5%, 1/4 w	
A4R3	0757-0200	R: fxd, met flm, 5.62 K $\pm$ 1%, 1/8 w	
A4R4	0757-1102	R: fxd, met flm, 180 ohms $\pm$ 1%, 1/8 w	
A4R5 and A4R6	0683-4725	R: fxd, comp, 4700 ohms $\pm$ 5%, 1/4 w	
A4R7	0683-2435	R: fxd, comp, 24 K $\pm$ 5%, 1/4 w	
A4R8	0683-3035	R: fxd, comp, 30 K $\pm$ 5%, 1/4 w	
A4R9	0683-1235	R: fxd, comp, 12 K $\pm$ 5%, 1/4 w	
A4R10	0683-1545	R: fxd, comp, 150 K $\pm$ 5%, 1/4 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A4R11	0683-6845	R: fxd, comp, 680 K $\pm 5\%$, 1/4 w	
A4R12	0683-1335	R: fxd, comp, 13 K $\pm 5\%$, 1/4 w	
A4R13	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A4R14	0683-1535	R: fxd, comp, 15 K $\pm 5\%$, 1/4 w	
A4R15	0683-2045	R: fxd, comp, 200 K $\pm 5\%$, 1/4 w	
A4R16	0757-0399	R: fxd, met flm, 82.5 ohms $\pm 1\%$, 1/8 w	
A4R17*	0757-0280	R: fxd, met flm, 1000 ohms $\pm 1\%$, 1/8 w	
A4R18	0698-3484	R: fxd, met flm, 6.65 K $\pm 1\%$, 1/8 w	
A4R19	0683-4715	R: fxd, comp, 470 ohms $\pm 5\%$, 1/4 w	
A4R20	0683-1845	R: fxd, comp, 180 K $\pm 5\%$, 1/4 w	
A4R21	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A4R22	0757-0280	R: fxd, met flm, 1000 ohms $\pm 1\%$, 1/8 w	
A4R23	0757-0283	R: fxd, met flm, 2000 ohms $\pm 1\%$, 1/8 w	
A4R24	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A4R25	0683-3045	R: fxd, comp, 300 K $\pm 5\%$, 1/4 w	
A4R26 and A4R27	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A4R28	0811-1370	R: fxd, prec ww, 10 K $\pm 0.1\%$, 1/4 w	
A4R29	0811-1371	R: fxd, prec ww, 1068 ohms $\pm 0.5\%$, 1/2 w	
A4R30	2100-1481	R: var, lin, ww, 50 ohms $\pm 5\%$, 3/4 w	
A4R31*	0683-1055	R: fxd, comp, 1 meg $\pm 5\%$, 1/4 w	
A4R32 and A4R33	0683-2225	R: fxd, comp, 2200 ohm $\pm 5\%$, 1/4 w	
A4R34	0683-3935	R: fxd, comp 39 K $\pm 5\%$, 1/4 w	
A4R35*	0683-2425	R: fxd, comp, 2400 ohms $\pm 5\%$, 1/4 w	
A4R36	0757-0399	R: fxd, met flm, 82.5 ohms $\pm 1\%$, 1/8 w	
A4R37	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A4TP1 thru A4TP3	0360-0124	Terminal: pin for 3/32" printed circuit board	
A5	03445-66505	Board assembly: ranging	
A5C1	0140-0198	C: fxd, dipped mica, 200 pf $\pm 5\%$	
A5C2	0160-0168	C: fxd, 0.1 μ f $\pm 10\%$, 200 vdcw	
A5C3	0140-0198	C: fxd, dipped mica, 200 pf $\pm 5\%$	
A5C4	0150-0071	C: fxd, cer die, 400 pf $\pm 5\%$, 500 vdcw	
A5C5 thru A5C10	0150-0069	C: fxd, cer die, 0.001 μ f $\pm 100\%$ -20%, 500 vdcw	
A5C11	0180-0100	C: fxd, solid tanta die, 4.7 μ f $\pm 10\%$, 35 vdcw	
A5C12	0180-0049	C: fxd, alum elect, 20 μ f, 50 vdcw	
A5CR1 thru A5CR22	1901-0025	Diode: Si, 100 ma at +1 v, 100 piv, 12 pf	
A5Q1	1850-0062	Transistor: special 2N404, germanium alloy junction	
A5Q2	1850-0111	Transistor: 2N404, PNP germanium	
A5Q3 thru A5Q10	1850-0062	Transistor: special 2N404, germanium alloy junction	
A5Q11	1850-0103	Transistor: 2N2190, PNP germanium	
A5Q12	1850-0062	Transistor: special 2N404, germanium alloy junction	
A5Q13	1853-0010	Transistor: PNP Si	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A5R1	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R2	0683-3925	R: fxd, comp, 3900 ohms $\pm 5\%$, 1/4 w	
A5R3 and A5R4	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R5	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R6	0683-9125	R: fxd, comp, 9100 ohms $\pm 5\%$, 1/4 w	
A5R7	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R8	0683-1025	R: fxd, comp, 1000 ohms $\pm 5\%$, 1/4 w	
A5R9	0683-1245	R: fxd, comp, 120 K $\pm 5\%$, 1/4 w	
A5R10	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R11	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R12	0683-3035	R: fxd, comp, 30 K $\pm 5\%$, 1/4 w	
A5R13	2100-0092	R: var, lin, 10 K $\pm 20\%$, 0.15 w	
A5R14	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R15	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R16	0683-3935	R: fxd, comp, 39 K $\pm 5\%$, 1/4 w	
A5R17	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R18	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R19	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R20	0683-2735	R: fxd, comp, 27 K $\pm 5\%$, 1/4 w	
A5R21	0683-2715	R: fxd, comp, 270 ohms $\pm 5\%$, 1/4 w	
A5R22	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R23	0683-3935	R: fxd, comp, 39 K $\pm 5\%$, 1/4 w	
A5R24	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R25	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R26	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R27	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R28		Not Assigned	
A5R29	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/4 w	
A5R30	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R31	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R32	0683-4745	R: fxd, comp, 470 K $\pm 5\%$, 1/4 w	
A5R33	0683-2715	R: fxd, comp, 270 ohms $\pm 5\%$, 1/4 w	
A5R34	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R35	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R36	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R37	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R38	0683-1055	R: fxd, comp, 1 meg $\pm 5\%$, 1/4 w	
A5R39	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R40	0683-4745	R: fxd, comp, 470 K $\pm 5\%$, 1/4 w	
A5R41 and A5R42	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R43	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R44	0683-4745	R: fxd, comp, 470 K $\pm 5\%$, 1/4 w	
A5R45	0683-2715	R: fxd, comp, 270 ohms $\pm 5\%$, 1/4 w	
A5R46	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R47	0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	
A5R48	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R49	0683-1055	R: fxd, comp, 1 meg $\pm 5\%$, 1/4 w	
A5R50	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A5R51	0683-3935	R: fxd, comp, 39 K $\pm 5\%$, 1/4 w	
A5R52	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R53	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R54	0683-3345	R: fxd, comp, 330 K $\pm 5\%$, 1/4 w	
A5R55	0683-4325	R: fxd, comp, 4300 ohms $\pm 5\%$, 1/4 w	
A5R56	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R57	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R58	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R59	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R60	0683-3935	R: fxd, comp, 39 K $\pm 5\%$, 1/4 w	
A5R61	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R62	0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	
A5R63	0683-2235	R: fxd, comp, 22 K $\pm 5\%$, 1/4 w	
A5R64	0683-4325	R: fxd, comp, 4300 ohms $\pm 5\%$, 1/4 w	
A5R65	0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	
A5R66	0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	
A5R67	0683-7535	R: fxd, comp, 75 K $\pm 5\%$, 1/4 w	
A5R68	0683-1055	R: fxd, comp, 1 meg $\pm 5\%$, 1/4 w	
A5R69	0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4 w	
A5TP1 thru A5TP3	0360-0124	Terminal: pin for 3/32" printed circuit board	
J2	1510-0006	Binding post: blk, without solder turret	
	1510-0008	Binding post: red, without solder turret	
	0340-0086	Insulator: BP double, without locking key	
	0340-0090	Insulator: BP double, with locking key	
	0340-0109	Insulator: threaded nylon, 6-32	
P6	1251-0099	Connector: 50 pin	
S1, S2	03445-61901	Switch assembly: rotary (includes components)	
	3100-1704	Switch assembly: rotary (without components) 2 sections, concentric shafts	
S1C1	0170-0066	C: fxd, 0.027 μ f, $\pm 10\%$	
S1R1	0683-5645	R: fxd, comp, 560 K $\pm 5\%$, 1/4 w	
		<u>MISCELLANEOUS</u>	
	03445-00101	Chassis	
	0370-0115	Knob: red, bar, pointer, 5/8" diam	
	0370-0088	Knob: round, 5/8" diam, black	
	0370-0113	Knob: skirted bar, 3/4" diam, black	
	1390-0029	Latch: fastener, clockwise locking, adjustable pawl	
	03445-90000	Manual	
	03445-00201	Panel: front	
	03445-00202	Panel: rear	
	03445-00203	Panel: sub	
	1200-0063	Receptacle: crimp type for 24 - 20 AWG insulated wire	
	03441-24701	Spacer	
	3050-0159	Washer: #6 nylon	

See introduction to this section

Table 6-2. Replaceable Parts

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ
0121-0116	C: var, air die, 2.2 - 17 pf	74970	189-8-5	1
0121-0127	C: var, air die, 1.7 - 11 pf	74970	189-5-5	1
0121-0131	C: var, air die, 1.2 - 3.5 pf	74970	189-1-5	2
0140-0145	C: fxd, dipped mica, 22 pf $\pm 5\%$	04062	RDM15C220J5C	1
0140-0198	C: fxd, dipped mica, 200 pf $\pm 5\%$	04062	RDM15F201J3C	2
0140-0204	C: fxd, dipped mica, 47 pf $\pm 5\%$	04062	RDM15E470J5C	3
0140-0206	C: fxd, dipped mica, 270 pf $\pm 5\%$	04062	RDM15F271J5C	1
0150-0069	C: fxd, cer die, 0.001 μf $\pm 100\%$ -20%, 500 vdcw	72982	801-010X5G0102Z	6
0150-0071	C: fxd, cer die, 400 pf $\pm 5\%$, 500 vdcw	56289	19C formulation 28	1
0150-0084	C: fxd, cer die, 0.1 μf $\pm 80\%$ -20%, 50 vdcw	56289	33C41	1
0150-0093	C: fxd, 0.01 μf $\pm 80\%$ -20%, 100 vdcw	91418	TA obd#	1
0160-0128	C: fxd, cer die, 2.2 μf $\pm 20\%$, 25 vdcw	56289	5C15 obd#	3
0160-0153	C: fxd, 0.001 μf $\pm 10\%$	56289	192P10292	1
0160-0168	C: fxd, 0.1 μf $\pm 10\%$, 200 vdcw	56289	192P10492	2
0160-0178	C: fxd, mica die, 27 pf $\pm 5\%$, 300 vdcw	04062	DM15E270J	2
0160-0996	C: fxd, disc cer, 0.01 μf $\pm 20\%$, 2000 vdcw	28480	0160-0996	1
0160-2008	C: set, fxd, 16 pf, 42 pf, 20 pf, 1940 pf, 145 pf	75275	VY Series obd#	1
0170-0038	C: fxd, my die, 0.22 μf $\pm 10\%$, 200 vdcw	56289	148P22492	1
0170-0040	C: fxd, my die, 0.047 μf $\pm 10\%$	56289	192P47392	1
0170-0066	C: fxd, 0.027 μf $\pm 10\%$	56289	192P27392	1
0180-0022	C: fxd, elect, solid tanta, 3.9 μf $\pm 10\%$, 35 vdcw	56289	150D395X9035B2	1
0180-0049	C: fxd, alum elect, 20 μf , 50 vdcw	56289	D33909	1
0180-0089	C: fxd, elect, 10 μf $\pm 100\%$ -10%, 150 vdcw	56289	30D106G150DF4	5
0180-0100	C: fxd, solid tanta die, 4.7 μf $\pm 10\%$, 35 vdcw	56289	150D475X9035B2	2
0180-0101	C: fxd, solid tanta die, 1.8 μf $\pm 10\%$, 35 vdcw	56289	150D185X9035B2	1
0180-0196	C: fxd, tanta elect, 56 μf $\pm 10\%$, 15 vdcw	56289	150D566X9015D2	1
0180-0228	C: fxd, tanta elect, 22 μf $\pm 10\%$, 10 vdcw	56289	150D226X9010B2	1
0340-0086	Insulator: BP double, without locating key	28480	0340-0086	1
0340-0090	Insulator: BP double, with locating key	28480	0340-0090	1
0340-0109	Insulator: threaded, nylon, 6-32	02768	212-160402-00- 0101	2
0360-0124	Terminal: pin, for 3/32" printed circuit board	71279	2970-3	6
0370-0088	Knob: round, 5/8" diam, black	28480	0370-0088	1
0370-0113	Knob: black, skirted var, 3/4" diam	28480	0370-0113	1
0370-0115	Knob: red, bar, 5/8" diam	28480	0370-0115	1
0490-0049	Relay: reed, SPST normally open	95348	MR830-1	1
0490-0158	Relay: reed, 1.5 pf, coil, contact	28480	0490-0158	5
0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4 w	01121	CB1015	1
0683-1025	R: fxd, comp, 1000 ohms $\pm 5\%$, 1/4 w	01121	CB1025	1
0683-1035	R: fxd, comp, 10 K $\pm 5\%$, 1/4 w	01121	CB1035	12
0683-1045	R: fxd, comp, 100 K $\pm 5\%$, 1/4 w	01121	CB1045	28
0683-1055	R: fxd, comp, 1 meg $\pm 5\%$, 1/4 w	01121	CB1055	1
0683-1235	R: fxd, comp, 12 K $\pm 5\%$, 1/4 w	01121	CB1235	1
0683-1245	R: fxd, comp, 120 K $\pm 5\%$, 1/4 w	01121	CB1245	1

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0683-1335	R: fxd, comp, 13 K $\pm 5\%$, 1/4 w	01121	CB1335	1	
0683-1535	R: fxd, comp, 15 K $\pm 5\%$, 1/4 w	01121	CB1535	1	
0683-1545	R: fxd, comp, 150 K $\pm 5\%$, 1/4 w	01121	CB1545	1	
0683-1845	R: fxd, comp, 180 K $\pm 5\%$, 1/4 w	01121	CB1845	2	
0683-2045	R: fxd, comp, 200 K $\pm 5\%$, 1/4 w	01121	CB2045	1	
0683-2225	R: fxd, comp, 2200 ohms $\pm 5\%$, 1/4 w	01121	CB2225	2	
0683-2235	R: fxd, comp, 22 K $\pm 5\%$, 1/4 w	01121	CB2235	2	
0683-2425	R: fxd, comp, 2400 ohms $\pm 5\%$, 1/4 w	01121	CB2425	4	
0683-2435	R: fxd, comp, 24 K $\pm 5\%$, 1/4 w	01121	CB2435	1	
0683-2715	R: fxd, comp, 270 ohms $\pm 5\%$, 1/4 w	01121	CB2715	3	
0683-2735	R: fxd, comp, 27 K $\pm 5\%$, 1/4 w	01121	CB2735	1	
0683-3035	R: fxd, comp, 30 K $\pm 5\%$, 1/4 w	01121	CB3035	2	
0683-3045	R: fxd, comp, 300 K $\pm 5\%$, 1/4 w	01121	CB3045	2	
0683-3335	R: fxd, comp, 33 K $\pm 5\%$, 1/4 w	01121	CB3335	6	
0683-3345	R: fxd, comp, 330 K $\pm 5\%$, 1/4 w	01121	CB3345	1	
0683-3925	R: fxd, comp, 3900 ohms $\pm 5\%$, 1/4 w	01121	CB3925	1	
0683-3935	R: fxd, comp, 39 K $\pm 5\%$, 1/4 w	01121	CB3935	4	
0683-4325	R: fxd, comp, 4300 ohms $\pm 5\%$, 1/4 w	01121	CB4325	2	
0683-4715	R: fxd, comp, 470 ohms $\pm 5\%$, 1/4 w	01121	CB4715	2	
0683-4725	R: fxd, comp, 4700 ohms $\pm 5\%$, 1/4 w	01121	CB4725	2	
0683-4735	R: fxd, comp, 47 K $\pm 5\%$, 1/4 w	01121	CB4735	21	
0683-4745	R: fxd, comp, 470 K $\pm 5\%$, 1/4 w	01121	CB4745	3	
0683-5645	R: fxd, comp, 560 K $\pm 5\%$, 1/4 w	01121	CB5645	1	
0683-5655	R: fxd, comp, 5.6 meg $\pm 5\%$, 1/4 w	01121	CB5655	1	
0683-6845	R: fxd, comp, 680 K $\pm 5\%$, 1/4 w	01121	CB6845	1	
0683-7535	R: fxd, comp, 75 K $\pm 5\%$, 1/4 w	01121	CB7535	3	
0683-9125	R: fxd, comp, 9100 ohms $\pm 5\%$, 1/4 w	01121	CB9125	1	
0686-3025	R: fxd, comp, 3000 ohms $\pm 5\%$, 1/2 w	01121	EB3025	1	
0686-6825	R: fxd, comp, 6800 ohms $\pm 5\%$, 1/2 w	01121	EB6825	8	
0692-6845	R: fxd, comp, 680 K $\pm 5\%$, 2 w	01121	HB6845	1	
0698-3308	R: set, fxd, met flm, 10 meg $\pm 5\%$, 1 w 5 meg $\pm 5\%$, 1/2 w 2.3 meg $\pm 5\%$, 1/4 w 580 K $\pm 5\%$, 1/8 w 50 K $\pm 5\%$, 1/8 w	56289	421E 420E 419E 419E 418E	1	
0698-3484	R: fxd, met flm, 6.65 K $\pm 1\%$, 3 w	75042	CEA T-O obd#	1	
0727-0955	R: fxd, carb flm, 10.5 ohms $\pm 1\%$, 1/2 w	0000T	CD1/2PR	1	
0757-0200	R: fxd, met flm, 5.62 K $\pm 1\%$, 1/8 w	19701	MF5C T-O	2	
0757-0280	R: fxd, met flm, 1000 ohms $\pm 1\%$, 1/8 w	75042	CEA T-O	2	
0757-0283	R: fxd, met flm, 2000 ohms $\pm 1\%$, 1/8 w	19701	MF5C T-O	2	
0757-0352	R: fxd, met flm, 150 K $\pm 1\%$, 1/2 w	75042	CEC T-O	1	
0757-0399	R: fxd, met flm, 82.5 ohms $\pm 1\%$, 1/8 w	75042	CEA T-O	2	
0757-0834	R: fxd, met flm, 5.62 K $\pm 1\%$, 1/2 w	75042	CEC T-O	2	
0757-1102	R: fxd, met flm, 180 ohms $\pm 1\%$, 1/8 w	75042	CEA T-O	1	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ
0811-1370	R: fxd, prec ww, 10 K $\pm 0.1\%$, 1/4 w	28480	0811-1370	1
0811-1371	R: fxd, prec ww, 1068 ohms $\pm 0.5\%$, 1/2 w	28480	0811-1371	1
1200-0063	Receptacle: crimp type for 24-20 AWG insulated wire	00779	42428-3	10
1205-0018	Heat sink: semiconductor for TO-18 for A3Q8	05820	NF-203 obd#	1
1205-0033	Heat sink: semiconductor for TO-5 for A3Q9	05820	NF-207 obd#	1
1251-0099	Connector: 50 pin	05820	NF-207 obd#	1
1251-0465	Connector: printed circuit, 22 tuning fork type contacts	74868	143-022-03-1105	3
1390-0029	Latch: fastener, clockwise locking, adjustable pawl	91079	48-99-137-22	1
1510-0006	Binding post: black, without solder turret	28480	1510-0006	1
1510-0008	Binding post: red, without solder turret	28480	1510-0008	1
1850-0062	Transistor: special 2N404, germanium alloy junction	01295	GA287 obd#	12
1850-0096	Transistor: 2N2189, PNP germanium	01295	2N2189	1
1850-0103	Transistor: 2N2190, PNP germanium	01295	2N2190	1
1850-0111	Transistor: 2N404A, PNP germanium	01295	2N404A	1
1850-0128	Transistor: 2N398B, PNP germanium	86684	34600	2
1853-0007	Transistor: 2N3251, PNP Si	04713	obd#	1
1853-0009	Transistor: PNP Si	07263	S 15097	7
1853-0010	Transistor: PNP Si	04713	SM4713	1
1854-0033	Transistor: 2N3391, NPN Si	24446	2N3391	7
1854-0039	Transistor: 2N3053, NPN Si	86684	2N3053	1
1854-0068	Transistor: NPN Si	86684	40264	1
1854-0069	Transistor: NPN Si	07263	S15032	1
1855-0004	Transistor: P channel	07256	U112 obd#	1
1901-0025	Diode: Si, 100 ma at +1 v, 100 piv, 12 pf	93332	D3072	34
1901-0027	Diode: Si, 2 ma at +1 v, 15 piv, 0.5 ns	73293	HD5004	3
1901-0040	Diode: Si, 30 ma at +1 v, 30 piv, 2 pf, 2 ns	07910	CD 6319	2
1901-0050	Diode: Si, 200 ma at +1 v, 2 pf, 2 ns, 75 v	03877	SG5140	2
1902-3124	Diode: Si, breakdown voltage 6.98 v $\pm 5\%$, 400 mw	01281	PS 18245A	1
1902-3259	Diode: Si, breakdown voltage 24.3 v $\pm 5\%$, 400 mw	01281	CD35817	1
1902-3345	Diode: Si, breakdown voltage 51.1 v $\pm 5\%$, 400 mw	01281	CD35910	1
1902-3404	Diode: Si, breakdown voltage 82.5 v $\pm 5\%$, 400 mw	04713	SZ10939-446	2
2100-0092	R: var, special, lin, 10 K $\pm 20\%$, 0.15 w	11237	UPE 70RE (hp)	1
2100-0396	R: var, ww, 10 K $\pm 20\%$, 1-1/2 w	79727	E-870 obd#	1
2100-1437	R: var, prec ww, 20 K $\pm 5\%$, 1 w	75042	106-2 obd#	1
2100-1481	R: var, lin ww, 50 ohms $\pm 5\%$, 3/4 w	12697	76JA3CM32464	1
2100-1523	R: var, prec ww, 2 K $\pm 5\%$, 1 w	75042	106-2 obd#	1
3050-0159	Washer: #6 nylon	28480	3050-0159	6
3100-1704	Switch: rotary, 2 sections, concentric shafts	76854	obd#	1
9100-1307	Inductor: var, printed circuit mounting, 60 - 180 μ h	28480	9100-1307	1

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
9100-1308	Inductor: fxd, printed circuit mount	28480	9100-1308	1	
9140-0137	Coil: fxd, RF, electromagnetic, 1000 μ h $\pm$ 5%	99800	2500-28	1	
9161-0013	Coil: electromagnetic, for single reed switch	28480	9161-0013	1	
03441-24701	Spacer	28480	03441-24701	2	
03445-00101	Chassis	28480	03445-00101	1	
03445-00201	Panel: front	28480	03445-00201	1	
03445-00202	Panel: rear	28480	03445-00202	1	
03445-00203	Panel: sub	28480	03445-00203	1	
03445-61201	Feedback ass'y	28480	03445-61201	1	
03445-61901	Switch ass'y: rotary	28480	03445-61901	1	
03445-66501	Board ass'y: master	28480	03445-66501	1	
03445-66503	Board ass'y: power supply	28480	03445-66503	1	
03445-66504	Board ass'y: converter	28480	03445-66504	1	
03445-66505	Board ass'y: ranging	28480	03445-66505	1	

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APPENDIX **CODE LIST OF MANUFACTURERS (Sheet 1 of 2)**

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
00500	U. S. A. Common	Any supplier of U. S.	07115	Corning Glass Works	Bradford, Pa.	24655	General Radio Co.	West Concord, Mass.	73293	Hughes Products Division of	
00136	McCoy Electronics	Mount Holly Springs, Pa.	07126	Electronic Components Dept.	Pasadena, Calif.	26365	Gries Reproductor Corp.	New Rochelle, N. Y.	73445	Amperex Electronics Co., Div. of North	Newport Beach, Calif.
00213	Sage Electronics Corp.	Rochester, N. Y.	07137	Transistor Electronics Corp.	Minneapolis, Minn.	26462	Grobet File Co. of America, Inc.	Carlstadt, N. J.	73506	American Phillips Co., Inc.	Hicksville, N. Y.
00334	Humidil Co.	Colton, Calif.	07138	Westinghouse Electric Corp.	Elmira, N. Y.	26992	Hamilton Watch Co.	Lancaster, Pa.	73490	Beckman Helipot Corp.	So. Pasadena, Calif.
00335	Westrex Corp.	New York, N. Y.	07149	Filmohm Corp.	New York, N. Y.	28480	Hewlett-Packard Co.	Palo Alto, Calif.	73506	Bradley Semiconductor Corp.	Hamden, Conn.
00373	Garlock Packing Co.,	Camden, N. J.	07233	Cinch-Graphik Co.	City of Industry, Calif.	33173	G. E. Receiving Tube Dept.	Owensboro, Ky.	73559	Carling Electric, Inc.	Hartford, Conn.
00656	Aerovox Corp.	New Bedford, Mass.	07261	Avnet Corp.	Los Angeles, Calif.	35434	Lectrohm Inc.	Chicago, Ill.	73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
00779	Amy, Inc.	Harrisburg, Pa.	07263	Fairchild Semiconductor Corp.	Mountain View, Calif.	36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada	73734	Federal Screw Prod. Co.	Chicago, Ill.
00781	Aircraft Radio Corp.	Boston, N. J.	07322	Minnesota Rubber Co.	Minneapolis, Minn.	37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.	73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.	07357	The Birtcher Corp.	Los Angeles, Calif.	40920	Mechanical Industries Prod. Co.	Akron, Ohio	73793	The General Industries Co.	Elyria, Ohio
00853	Sangamo Electric Company,		07700	Technical Wire Products	Springfield, N. J.	42190	Miniature Precision Bearings, Inc.	Keene, N. H.	73846	Goshen Stamping & Tool Co.	Goshen, Ind.
	Drill Division (Capacitors)	Marion, Ill.	07910	Continental Device Corp.	Hawthorne, Calif.	43990	C. A. Norgren Co.	Englewood, Colo.	73899	JFD Electronics Corp.	Brooklyn, N. Y.
00866	Goe Engineering Co.	Los Angeles, Calif.	07933	Rheem Semiconductor Corp.	Mountain View, Calif.	44555	Ohmite Mfg. Co.	Skokie, Ill.	73905	Jennings Radio Mfg. Co.	San Jose, Calif.
00891	Carl E. Holmes Corp.	Milwaukee, Wis.	07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.	47904	Polaroid Corp.	Cambridge, Mass.	74276	Signalite Inc.	Neptune, N. J.
01121	Allen Bradley Co.	Beverly Hills, Calif.	07980	Boonton Radio Corp.	Boston, N. J.	48620	Precision Thermometer and	Philadelphia, Pa.	74455	J. H. Winns, and Sons	Winchester, Mass.
01255	Liton Industries, Inc.	Lawlode, Calif.	08145	U. S. Engineering Co.	Los Angeles, Calif.		Inst. Co.	Lexington, Mass.	74861	Industrial Condenser Corp.	Chicago, Ill.
01281	TRW Semiconductors, Inc.		08289	Bluma, Delbert Co.	Pomona, Calif.	49956	Raytheon Company	Baltimore, Md.	74868	R. F. Products Division of Ampheno-	Danbury, Conn.
01295	Texas Instruments, Inc.	Dallas, Texas	08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada	52090	Rowan Controller Co.	Baltimore, Md.		Borg Electronics Corp.	Wesaca, Minn.
01349	The Alliance Mfg. Co.	Alliance, Ohio	08717	Sloan Company	Burbank, Calif.	52743	Ward Leonard Electric	MT. Vernon, N. Y.	74970	E. F. Vernon, N. Y.	Wesaca, Minn.
01561	Chassi-Trak Corp.	Indianapolis, Ind.	08718	Canon Electric Co., Phoenix Div.	Phoenix, Ariz.	54294	Shallcross Mfg. Co.	Selma, N. C.	75042	International Resistance Co.	Philadelphia, Pa.
01589	Carrier Relays, Inc.	Van Nuys, Calif.	08792	CBS Electronics Division	Lowell, Mass.	55026	Simpson Electric Co.	Chicago, Ill.	75173	Jones, Howard B., Division	Chicago, Ill.
01930	Amerock Corp.	Rockford, Ill.	08984	Mel-Rain	Indianapolis, Ind.	55933	Sontone Corp.	Elmsford, N. Y.		of Cinch Mfg. Corp.	Chicago, Ill.
01961	Pulse Engineering Corp.	Santa Clara, Calif.	09026	Babcock Relays, Inc.	Costa Mesa, Calif.	55938	Sorenson & Co., Inc.	So. Norwalk, Conn.	75378	James Knights Co.	Sandwich, Ill.
02114	Ferrocube Corp. of America	Palo Alto, Calif.	09134	Texas Capacitor Co.	Houston, Texas	56137	Spaulding Fibre Co., Inc.	Tonawanda, N. Y.	75382	Kaika Electric Corporation	MT. Vernon, N. Y.
02286	Cole Mfg. Co.	Chicago, Ill.	09145	Atcham Electronics	San Valley, Calif.	56289	Soragae Electric Co.	North Adams, Mass.	75818	Lenz Electric Mfg. Co.	Des Plaines, Ill.
02660	Amphenol-Borg Electronics Corp.	Somerville, N. J.	09250	Electro Assemblies, Inc.	Chicago, Ill.	59446	Telex, Inc.	St. Paul, Minn.	75915	Littlefuse Inc.	Des Plaines, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N. J.	09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada	59730	Thomas & Belts Co.	Elizabethtown, N. J.	76005	Lord Mfg. Co.	Erie, Pa.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.	09664	The Bristol Co.	Waterbury, Conn.	60741	Tripplett Electrical Inc.	Bluffton, Ohio	76210	C. W. Marwedel	San Francisco, Calif.
02777	Hopkins Engineering Co.	San Fernando, Calif.	10214	General Transistor Western Corp.	Los Angeles, Calif.	61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.	76433	Micamold Electronic Mfg. Corp.	Brooklyn, N. Y.
02998	G. E. Semiconductor Products Dept.	Syracuse, N. Y.	10411	Ti-Tai, Inc.	Berkeley, Calif.	62119	Universal Electric Co.	Dwoss, Mich.	76487	James Millen Mfg. Co., Inc.	Malden, Mass.
03705	Apex Machine & Tool Co.	Dayton, Ohio	10412	General Transistor Western Corp.	Los Angeles, Calif.	63743	Ward-Leonard Electric Co.	MT. Vernon, N. Y.	76493	J. W. Miller Co.	Los Angeles, Calif.
03797	Edema Corp.	El Monte, Calif.	10646	Carborundum Co.	Niagara Falls, N. Y.	64959	Western Electric Co., Inc.	New York, N. Y.	76530	Monadnock Mills	San Leandro, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.	11236	CTS of Berne, Inc.	Berne, Ind.	65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N. J.	76545	Mueller Electric Co.	Cleveland, Ohio
03888	Pyrofilm Resistor Co.	Morrisstown, N. Y.	11237	Chicago Telephone Co. of California, Inc.	So. Pasadena, Calif.	65295	Wittels Manufacturing Co.	Chicago 23, Ill.	76854	Oak Manufacturing Co.	Crystal Lake, Ill.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.	11312	Microwave Electronics Corp.	Palo Alto, Calif.	66346	Wittels Optical Co.	Rochester, N. Y.	77075	Pacific Metals Co.	No. Hollywood, Calif.
04009	Airrow, Hart and Hegeman Elect. Co.	Hartford, Conn.	11534	Duncan Electronic, Inc.	Santa Ana, Calif.	67076	Allen Mfg. Co.	Hartford, Conn.	77221	Phosatron Instrument and Electronic Co.	South Pasadena, Calif.
04013	Taurus Corp.	Lambertville, N. J.	11711	General Instrument Corporation Semiconductor Division	Newark, N. J.	70319	Altmetel Screen Prod. Co., Inc.	Garden City, N. Y.	77250	Phoel Mfg. Co.	Chicago, Ill.
04062	Elenco Products Co.	New York, N. Y.	11717	Imperial Electronic, Inc.	Buena Park, Calif.	70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.	77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S. C.	11870	Melabs, Inc.	Palo Alto, Calif.	70563	Apertite Co., Inc.	New York, N. Y.	77342	Peltier and Brumfield, Div. of American	Princeton, Ind.
04298	Elgin National Watch Co.	Burbank, Calif.	12136	Philadelphia Handle Co.	Camden, N. J.	70993	Bendite Mfg. Co.	Chicago, Ill.		Machine and Foundry	Princeton, Ind.
04354	Precision Paper Tube Co.	Chicago, Ill.	12697	Claroat Mfg. Co.	Dover, N. H.	70998	Bird Electronic Corp.	Cleveland, Ohio	77630	Radio Condenser Co.	Camden, N. J.
04454	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.	12859	Nippon Electric Co., Ltd.	Tokyo, Japan	71002	Birmbach Radio Co.	New York, N. Y.	77638	Radio Receptor Co., Inc.	Brooklyn, N. Y.
04651	Sylvania Electric Prods., Inc.	Mountain View, Calif.	12930	Delta Semiconductor Inc.	Newport Beach, Calif.	71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.	77664	Resistance Products Co.	Harrisburg, Pa.
04713	Metrolite, Inc., Semiconductor Prod. Div.	Phoenix, Arizona	13103	Thermolyt	Dallas, Texas	71218	Bud Radio Inc.	Cleveland, Ohio	77969	Rubercraft Corp. of Calif.	Torrance, Calif.
04732	Filtrol Co., Inc., Western Div.	Culver City, Calif.	13396	Telefunken (G. M. B. H.)	Hannover, Germany	71286	Camloc Fastener Corp.	Paramus, N. J.	78189	Shakeproof Division of Illinois	Elgin, Ill.
04773	Automatic Electric Co.	Northlake, Ill.	13835	Midland Mfg. Co.	Kansas City, Kansas	71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.	78283	Signal Indicator Corp.	New York, N. Y.
04777	Automatic Electric Sales Corp.	Northlake, Ill.	14059	Sam-Tech	Newbury Park, Calif.	71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.	78290	Struthers-Dunn Inc.	Pittman, N. J.
04796	Sequia Wire & Cable Co.	Redwood City, Calif.	14193	Calif. Resistor Corp.	Santa Monica, Calif.	71436	Chicago Condenser Corp.	Chicago, Ill.	78452	Thompson-Brenner & Co.	Chicago, Ill.
04811	Precision Coil Spring Co.	El Monte, Calif.	14296	American Components, Inc.	Coshocton, Pa.	71450	CTS Corp.	Elkhart, Ind.	78471	Tilly Mfg. Co.	San Francisco, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.	14555	Cornell Duplicator Elec. Corp.	So. Plainfield, N. J.	71468	Canon Electric Co.	Los Angeles, Calif.	78488	Stackpole Carbon Co.	St. Marys, Pa.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.	14960	Williams Mfg. Co.	San Jose, Calif.	71471	Cinema Engineering Co.	Burbank, Calif.	78493	Standard Thomson Corp.	Waltham, Mass.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.	15203	Webster Electronics Co. Inc.	Brooklyn, N. Y.	71482	C. P. Clare & Co.	Chicago, Ill.	78553	Tinnerman Products, Inc.	Cleveland, Ohio
05347	Ultratronics, Inc.	San Mateo, Calif.	15291	Adjustable Bushing Co.	N. Hollywood, Calif.	71590	Central Div. of Globe Union Inc.	Chicago, Wis.	78790	Transformer Engineers	Passadena, Calif.
05593	Humitronics Engineering Co.	Sunnyvale, Calif.	15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.	71616	Commercial Plastics Co.	Chicago, Ill.	78947	Ucinco Co.	Hartford, Conn.
05616	Cosmo Plastic	Cleveland, Ohio	15909	The Daven Co.	Livingston, N. J.	71700	The Cornish Wire Co.	New York, N. Y.	79142	Veeder Root, Inc.	Chicago, Ill.
05624	Barber Colman Co.	Rockford, Ill.	16037	Spruce Pine Mica Co.	Spruce Pine, N. C.	71744	Chicago Miniature Lamp Works	Chicago, Ill.	79251	Wenco Mfg. Co.	Chicago, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N. Y.	16392	Computer Diode Corp.	Lodi, N. J.	71753	A. D. Smith Corp., Crowley Div.	West Orange, N. J.	79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
05729	Metropolitan Telecommunications Corp., Inc.	Brooklyn, N. Y.	16688	De Jure-Amco Corporation	Long Island City 1, N. Y.	71785	Cinch Mfg. Corp.	Chicago, Ill.	79963	Zierlich Mfg. Corp.	New Rochelle, N. Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.	17109	Thermionics Inc.	Canoga Park, Calif.	71984	Dow Corning Corp.	Midland, Mich.	80031	Mapco Division of Sessions	Morrisstown, N. J.
05820	Wakefield Engineering Inc.	Bridgeport, Conn.	17474	Tronex Company	Mountain View, Calif.	72092	Eitel-McCullough, Inc.	San Bruno, Calif.	80120	Schnitzer Alloy Products	Elizabeth, N. J.
06004	The Bossick Co.	Bridgeport, Conn.	18486	Radio Industries	Des Plaines, Ill.	72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.	80130	Times Facsimile Corp.	New York, N. Y.
06175	Bausch and Lomb Optical Co.	Rochester, N. Y.	18583	Curtis Instrument Inc.	ML. Kisco, N. Y.	721707	Coto Coil Co., Inc.	Providence, R. I.	80131	Electronic Industries Association	Washington, D. C.
06402	E. T. A. Products Co. of America	Chicago, Ill.	18873	E. J. DuPont & Co., Inc.	Wilmington, Del.	72354	John E. Fast & Co.	Chicago, Ill.	80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
06475	Western Devices, Inc.	Ingleswood, Calif.	19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N. J.	72619	Dialight Corp.	Brooklyn, N. Y.	80223	United Transformer Corp.	New York, N. Y.
06540	Anatom Electronic Hardware Co., Inc.	New Rochelle, N. Y.	19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N. J.	72656	General Ceramics Corp.	Keasbey, N. J.	80248	Electrolite Electric Corp.	Chicago, Ill.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N. H.	19701	Electra Manufacturing Co.	West Orange, N. J.	72699	General Instrument Corp., Semiconductor Div.	Newark, N. J.	80294	Bourns Laboratories, Inc.	Riverside, Calif.
06751	U. S. Sencor Division of Nuclear Corp. of America	Phoenix, Arizona	20183	Electronic Tube Corp.	Philadelphia, Pa.	72758	Girard-Hopkins	Oakland, Calif.	80411	Acro Div. of Robertshaw	Columbus 16, Ohio
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.	21226	Executive, Inc.	New York, N. Y.	72765	Drake Mfg. Co.	Chicago, Ill.	80486	All Star Products Inc.	Defiance, Ohio
07088	Keivn Electric Co.	Van Nuys, Calif.	21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.	72825	Hugh H. Eby Inc.	Philadelphia, Pa.	80509	Avery Adhesive Label Corp.	Monrovia, Calif.
			21635	The Fafnir Bearing Co.	New Britain, Conn.	72928	Gudeman Co.	Chicago, Ill.	80543	Hammerlund Co., Inc.	New York, N. Y.
			21964	Fed. Telephone and Radio Corp.	Clifton, N. J.	72964	Robert M. Hadley Co.	Los Angeles, Calif.	80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
			24446	General Electric Co.	Schenectady, N. Y.	72982	Erie Resistor Corp.	Erie, Pa.	81030	International Instruments, Inc.	New Haven, Conn.
			24455	G. E. Lamp Division	Nela Park, Cleveland, Ohio	73081	Hansen Mfg. Co., Inc.	Princeton, Ind.	81073	Grayhill Co.	LaGrange, Ill.
						73076	H. M. Harper Co.	Chicago, Ill.	81095	Triad Transformer Corp.	Venice, Calif.
						73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.	81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

APPENDIX **CODE LIST OF MANUFACTURERS (Sheet 2 of 2)**

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
81349	Military Specification		85474	R.M. Bracamonte & Co.	San Francisco, Calif.	93929	G. V. Controls	Livingston, N. J.	98220	Francis L. Masley	Pasadena, Calif.
81415	Wilcor Products, Inc.	Cleveland, Ohio	85560	Kotied Kords, Inc.	New Haven, Conn.	93983	Insuline-Van Norman Ind., Inc.		98278	Microdot, Inc.	So. Pasadena, Calif.
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.	85911	Seamless Rubber Co.	Chicago, Ill.	94137	Electronic Division	Manchester, N.H.	98291	Sealex Corp.	Mamaroneck, N.Y.
81483	International Rectifier Corp.	El Segundo, Calif.	86197	Clifton Precision Products	Clifton Heights, Pa.	94144	General Cable Corp.	Bayonne, N.J.	98405	Carad Corp.	Redwood City, Calif.
81541	The Airpak Products Co.	Cambridge, Mass.	86579	Precision Rubber Products Corp.	Dayton, Ohio	94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.	98731	General Mills	Minneapolis, Minn.
81650	Barry Controls, Inc.	Watertown, Mass.	86684	Radio Corp. of America, RCA	Harrison, N.J.	94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.	98821	North Hills Electric Co.	Mineola, N.Y.
82042	Carier Parts Co.	Skokie, Ill.	87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.	94148	Scientific Radio Products, Inc.	Loveland, Colo.	98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
82142	Jeffers Electronics Division of Spear Carbon Co.	Dr Bois, Pa.	87473	Western Fibrous Glass Products Co.	San Francisco, Calif.	94154	Tung-Sol Electric, Inc.	Newark, N.J.	98978	International Electronic Research Corp.	Burbank, Calif.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.	87664	Van Waters & Rogers Inc.	Seattle, Wash.	94197	Curtis-Wright Corp., Electronics Div.	East Paterson, N.J.	99109	Columbia Technical Corp.	New York, N.Y.
82209	Maguire Industries, Inc.	Greenwich, Conn.	87930	Tower Mfg. Corp.	Providence, R. I.	94222	Southco Div. of S. Chester Corp.	Lester, Pa.	99313	Varian Associates	Palo Alto, Calif.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emperium, Pa.	88140	Cutler-Hammer, Inc.	Lincoln, Ill.	94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.	99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
82376	Astron Co.	East Newark, N.J.	88220	Gould-National Batteries, Inc.	St. Paul, Minn.	94330	Wire Cloth Products Inc.	Chicago, Ill.	99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
82389	Switchcraft, Inc.	Chicago, Ill.	88698	General Mills, Inc.	Buffalo, N.Y.	94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.	99800	DeJavan Electronics Corp.	East Aurora, N.Y.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.	89462	Waltes Kohinor, Inc.	Oakland, Calif.	95023	Philbrick Researchers, Inc.	Boston, Mass.	99848	Wilco Corporation	Indianapolis, Ind.
82865	Research Products Corp.	Madison, Wis.	89473	General Electric Distributing Corp.	Schenectady, N.Y.	95236	Allies Products Corp.	Miami, Fla.	99934	Renbrandt, Inc.	Boston, Mass.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.	89636	Carier Parts Div. of Economy Baler Co.	Chicago, Ill.	95238	Continental Connector Corp.	Woodside, N.Y.	99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
82893	Vector Electronic Co.	Glendale, Calif.	89665	United Transformer Co.	Chicago, Ill.	95263	Leercraft Mfg. Co., Inc.	New York, N.Y.	99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.	90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.	95264	Lenco Electronics, Inc.	Burbank, Calif.	THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.		
83058	Carr Fastener Co.	Cambridge, Mass.	90970	Bearing Engineering Co.	San Francisco, Calif.	95265	National Coil Co.	Sheridan, Wyo.			
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.	91260	Connor Spring Mfg. Co.	San Francisco, Calif.	95275	Vitramon, Inc.	Bridgeport, Conn.			
83125	Pyramid Electric Co.	Darlington, S.C.	91345	Miller Dial & Nameplate Co.	El Monte, Calif.	95348	Gordas Corp.	Bloomfield, N.J.	J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.	91418	Radio Materials Co.	Chicago, Ill.	95354	Methode Mfg. Co.	Chicago, Ill.	0000F	Malco Tool and Die	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.	91506	Augat Brothers, Inc.	Attleboro, Mass.	95712	Dage Electric Co., Inc.	Franklin, Ind.	0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.	91662	Dale Electronics, Inc.	Columbus, Nebr.	95987	Weckesser Co.	Chicago, Ill.	0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
83315	Hubbell Corp.	Mundelein, Ill.	91737	Elco Corp.	Philadelphia, Pa.	96067	Huggins Laboratories	Sunnyvale, Calif.	0000Z	Willow Leather Products Corp.	Newark, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.	91737	Gremar Mfg. Co., Inc.	Wakelield, Mass.	96095	Hi-Q Division of Aerovox	Olean, N.Y.	000AA	British Radio Electronics Ltd.	Washington, D.C.
83385	Central Screw Co.	Chicago, Ill.	91827	K F Development Co.	Redwood City, Calif.	96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.	000AB	ETA	England
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.	91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.	96296	Solar Manufacturing Co.	Los Angeles, Calif.	000AC	Indiana General Corp., Elect. Div.	Indiana
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.	91961	Nahm-Bros. Spring Co.	Oakland, Calif.	96330	Carlton Screw Co.	Chicago, Ill.	000BB	Precision Instrument Components Co.	Van Nuys, Calif.
83740	Eveready Battery	New York, N.Y.	92180	Tri-Connector Corp.	Peabody, Mass.	96341	Microwave Associates, Inc.	Burlington, Mass.	000MM	Rubber Eng. & Development	Hayward, Calif.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.	92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.	96501	Excel Transformer Co.	Oakland, Calif.	000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
83821	Loyd Scruggs Co.	Festus, Mo.	92367	Elgeet Optical Co., Inc.	Rochester, N.Y.	97454	Industrial Retaining Ring Co.	Irvine, N.J.	000QQ	Cooltron	Oakland, Calif.
84171	Arco Electronics, Inc.	New York, N.Y.	92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.	97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.	000SS	Control of Elgin Watch Co.	Burbank, Calif.
84396	A.J. Giesener Co., Inc.	San Francisco, Calif.	93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.	97968	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.	000WW	California Eastern Lab.	Burlingame, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.	93369	Robbins and Myers, Inc.	New York, N.Y.	97979	Reon Resistor Corp.	Yonkers, N.Y.	000YY	S.K. Smith Co.	Los Angeles 45, Calif.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.	93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio	98141	Axel Brothers Inc.	Jamaica, N.Y.			
84954	Bounton Molding Company	Bounton, N.J.	93788	Howard J. Smith Inc.	Port Monmouth, N. J.	98159	Rubber Teck, Inc.	Gardena, Calif.			
85471	A.B. Boyd Co.	San Francisco, Calif.									

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